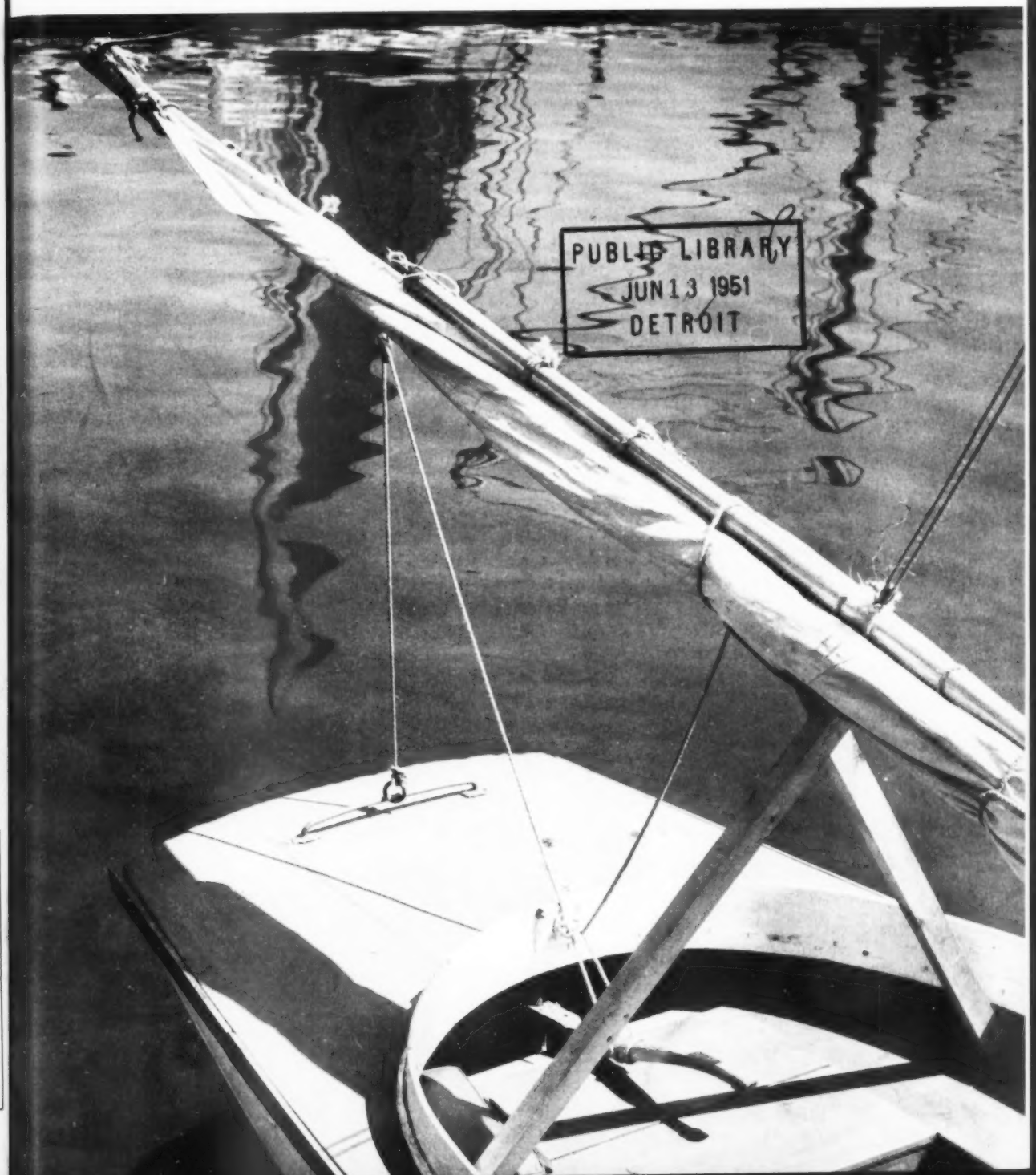
TECHNOLOGY REVIEW

TECHNOLOGY DEPT.

June 1951



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Co-operation with Schools to Stimulate Interest of Graduate Students

To gain valuable industrial experience before starting to study for his Doctor's degree, Robert D. Haberstroh worked at the Westinghouse Research Laboratories during his 1950 vacation. He is shown preparing to run a test on a combustion chamber for a gas turbine. Mr. Haberstroh, a native of Johnstown, Pa., was graduated under the George Westinghouse Scholarship Program from Carnegie Institute of Technology last year with a Bachelor's Degree in mechanical engineering.

For more than half a century, Westinghouse has placed major emphasis on co-operating with educational institutions in the process of building men for positions of leadership. It was a pioneer in providing orientation and training programs for newly employed college graduates and in offering all employees opportunities for advanced degree work in co-operation with local universities. It has also been a leader in encouraging higher education in science and engineering through a large-scale program of scholarships and fellowships.

One of the latest additions to this broad program is a plan to co-operate with engineering schools in their advanced work by supplementing technical training with actual research experience.

Through this plan, selected students in graduate schools who are interested in the field of research are given the opportunity to get practical laboratory experience. During summer months, 10 outstanding students selected from engineering schools are given the opportunity to gain experience in the Westinghouse Research Laboratories.

Working beside seasoned research people, these young scientists gain firsthand experience in industrial research practices and techniques. Besides gaining much practical experience and valuable counsel, they earn while they learn.

Through this co-operation with colleges, Westinghouse hopes to aid students in choosing the scientific field they should enter, and, at the same time, strengthen their foundation for graduate school work.

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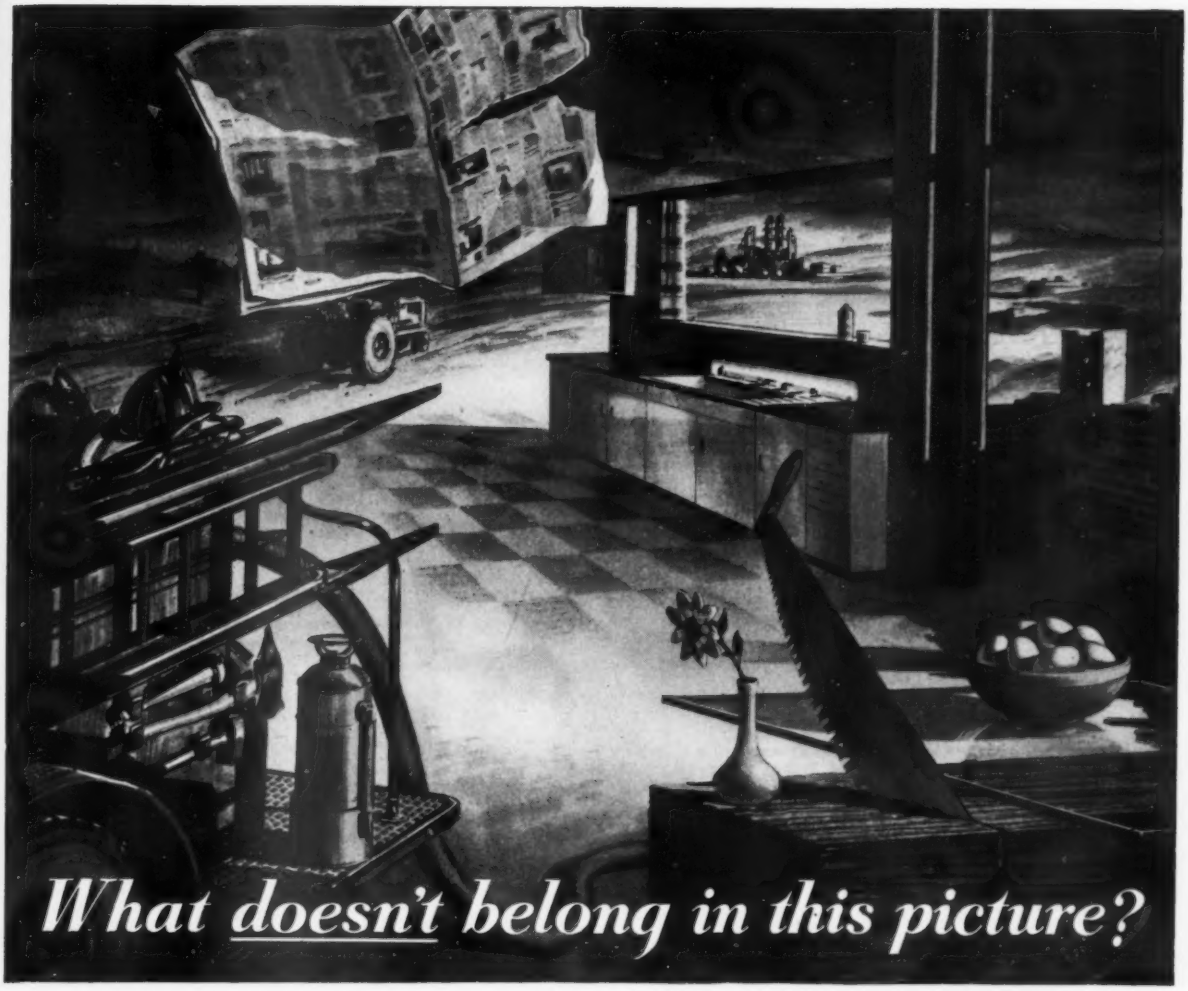

All but one of the objects in this picture have something in common. They were affected directly or indirectly by the kind of products Norton and Behr-Manning make. *Can you find the stranger?*

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The newspaper? No! Norton pulpstones ground the wood from which it's made. Norton and Behr-Manning abrasive products helped build the press that printed it.

The eggs? Surprisingly, no! Many farmers clean them with Behr-Manning coated abrasives.

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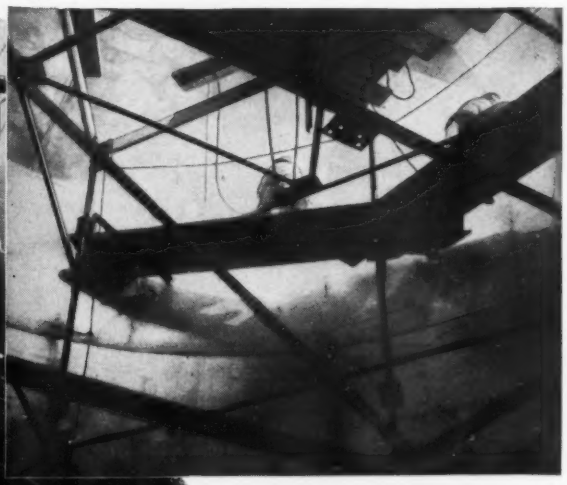
Another example of GRAVER *skill!*

GRAVER

FIELD ERECTION IN ALLOYS



Graver welders at work on field erection of nickel-clad chemical tanks.

Exterior view of two butt-welded, nickel-clad storage tanks. Capacity: 2,100 bbls. each. Size: 25' O.D. x 24'.

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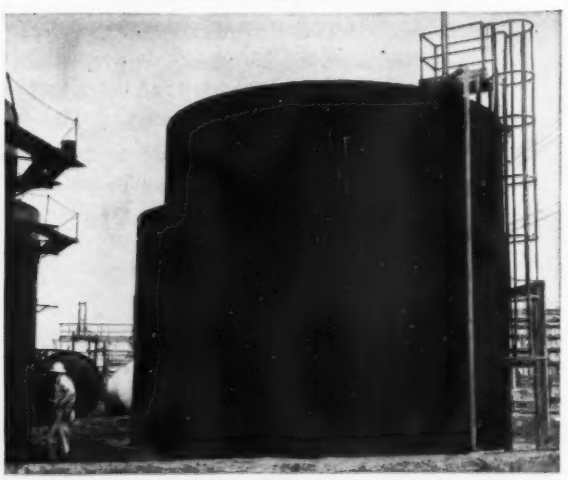

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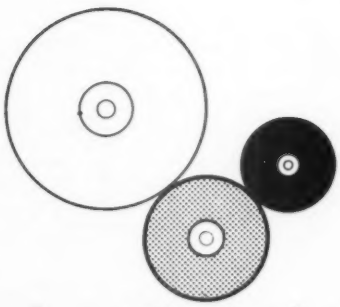

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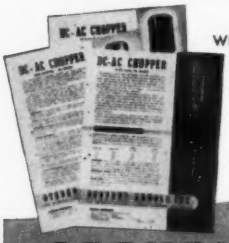

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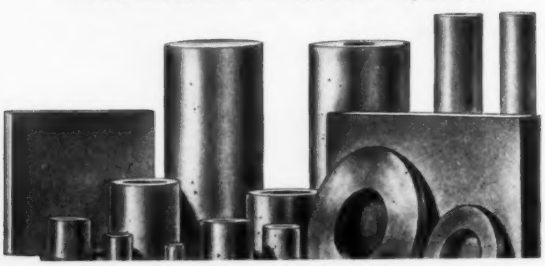

THE TABULAR VIEW

Merchant Marine. — Under present circumstances, the nation's merchant marine needs vessels of such design as to be capable of rapid production in large quantities and of greater speed than the Liberty and Victory ships which carried a large part of cargo on ocean lanes during World War II. A review of the U. S. Maritime Administration's program for building such a fleet is described (page 407) by EDWARD L. COCHRANE, '20. A graduate of the United States Naval Academy, as well as of Technology, Admiral Cochrane has had a distinguished career in naval and educational circles. He holds honorary doctorate degrees from the Hahnemann Medical College and the Polytechnic Institute of Brooklyn, is a knight commander, Order of the British Empire, was awarded the Grand Cordon by China, and is a member of the National Academy of Sciences and the United States Naval Institute. He served on the staff of the Commander Scouting Force of the United States Fleet from 1933 to 1935; between 1935 and 1939, was administrator for the Bureau of Construction and Repair; served as naval attaché at the American Embassy in London; became chief of the Bureau of Ships in 1942; and subsequently was appointed chief of the material division, United States Navy. He became head of the Institute's Department of Naval Architecture and Marine Engineering in 1947, and is now on leave to serve as Maritime Administrator.

Impressive Implement. — A major contribution to the Institute's educational and research facilities will be dedicated during a three-day symposium on hydrodynamics to be held on June 4 to 6. First of the major projects to be completed by funds raised during the recent Development Fund Program, the new Hydrodynamics Laboratory provides extensive laboratory facilities for teaching and research in hydrodynamics. The new laboratory is an impressive implement, indeed, whose purpose, planning, and utilization are described (page 399) by Professor ARTHUR T. IPPEN of the Department of Civil and Sanitary Engineering, Director of the Hydrodynamics Laboratory. Native of London, Dr. Ippen was graduated from the Technical University of Aachen, Germany, in 1931, and then became exchange fellow at the Institute of Hydraulic Research at the University of Iowa. He was teaching and research fellow at the California Institute of Technology from 1934 to 1937, from which institution he received the M.S. and Ph.D. degrees in 1935 and 1936, respectively. He joined the faculty of Lehigh University in 1938, and became a member of the Technology Faculty in 1945 as associate professor, and in 1948 he was promoted to full professor.

Towing Tank. — Completed a few months ago, the Institute's Ship Model Towing Tank has been in use by students since last February. The tank, a significant portion of the Hydrodynamics Laboratory, will be dedicated at a symposium on June 4 to 6. Interesting features of the tank are described (page 404) by MARTIN A. ABKOWITZ, Assistant Professor of Naval Architecture. Professor Abkowitz received the S.B. degree in Naval Architecture from M.I.T. in 1940 and the M.A. degree in physics in 1949 from Harvard, where he is a candidate for the Ph.D. degree. During World War II he was an officer in the United States Army, and from 1946 to 1949 was physicist at the David Taylor Model Basin in Washington, working on problems of ship control.

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MAIL RETURNS

More M.I.T.

FROM WESLEY HALLIBURTON, '92:

Two volumes of The Review lie on my table, but one must search inside the volumes to determine if they are a scientific school publication or just a technological publication. Why not the following on the cover?

M.I.T.
Technology
Review — July 1951

I feel a high sense of values in the work that M.I.T. is doing. I consider it the greatest technological school of the day, including the world.

Memphis, Tenn.

Instruments Intact

FROM THOMAS DOANE PERRY, '00:

I have read with great interest the article "The Blasted Bore" in the January Review, particularly as I seem to be the family member on whom have been wished most of the data relating to the genealogy and history of the clan. The family story of the Hoosac Tunnel, to which a certain amount of pardonable luster has been added in the retelling through the generations, runs about as follows:

My grandfather, Thomas Doane, was employed as chief engineer in October, 1863, shortly after the project had been taken over by the state. He reduced to a straight line the earlier curved course that had been projected, and completed the survey with two specially made transits, more accurate than had been previously available. Grandfather was a determined individualist of keen insight, and resigned in 1867, because of the meddlesome political control — a control which became so intolerable, that a private contractor was engaged late in 1868. After six years in railroad building in the West, grandfather was re-employed on the Hoosac Tunnel by the private contractor, Shanly. He ran the first engine through the tunnel in 1875.

The two transits, used for tunnel alignment, are preserved: one at the Blue Hills Observatory, near Boston; and the other at Doane College, Crete, Neb., where it is mounted and available to verify sidereal time.

Moorestown, N.J.

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As a result, the people of Union Carbide are already providing allethrin in ever-increasing quantities to manufacturers of household and dairy sprays. And researchers all over the country are now engaged in testing its value for the control of agricultural pests and for other purposes. Other Union Carbide chemicals are important ingredients in many other insecticides and fungicides. One or more of them may have a place in your future plans.

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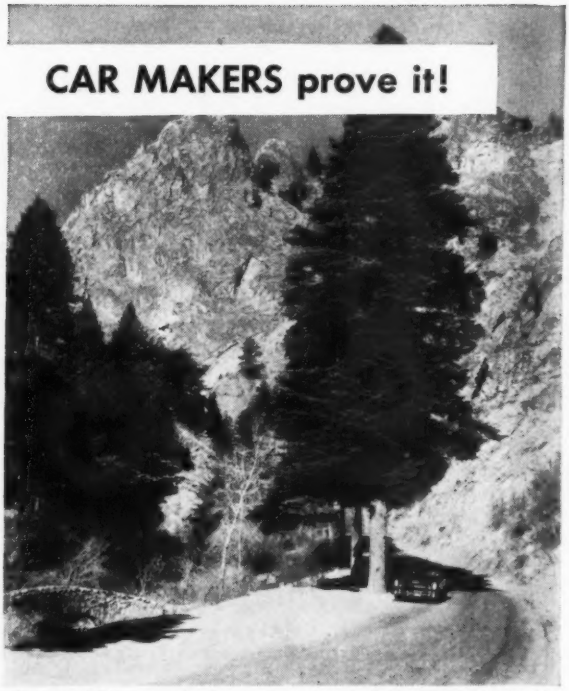
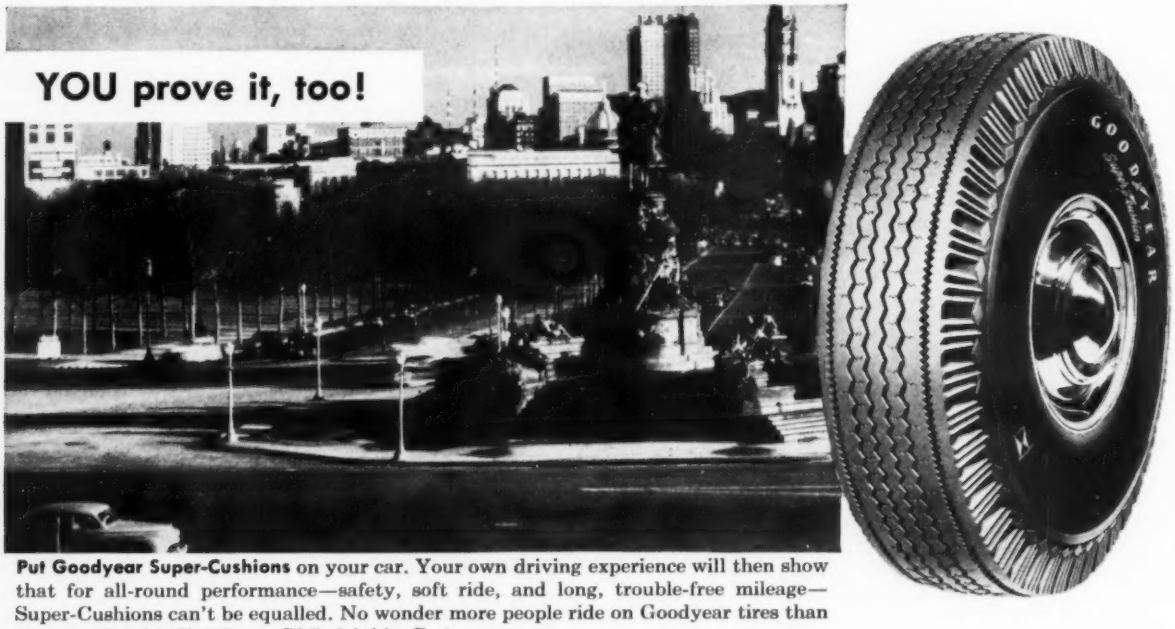


Automobile manufacturers test-drive their cars on all kinds of roads, such as this one at Cheyenne Canyon, Colo. These automobile manufacturers in Detroit, motor capital of the world, really know tires and *put more Goodyear Super-Cushions on the new cars than any other tire.*



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More people ride on Goodyear tires than on any other kind

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C. E. Patch, '02

THE TECHNOLOGY REVIEW

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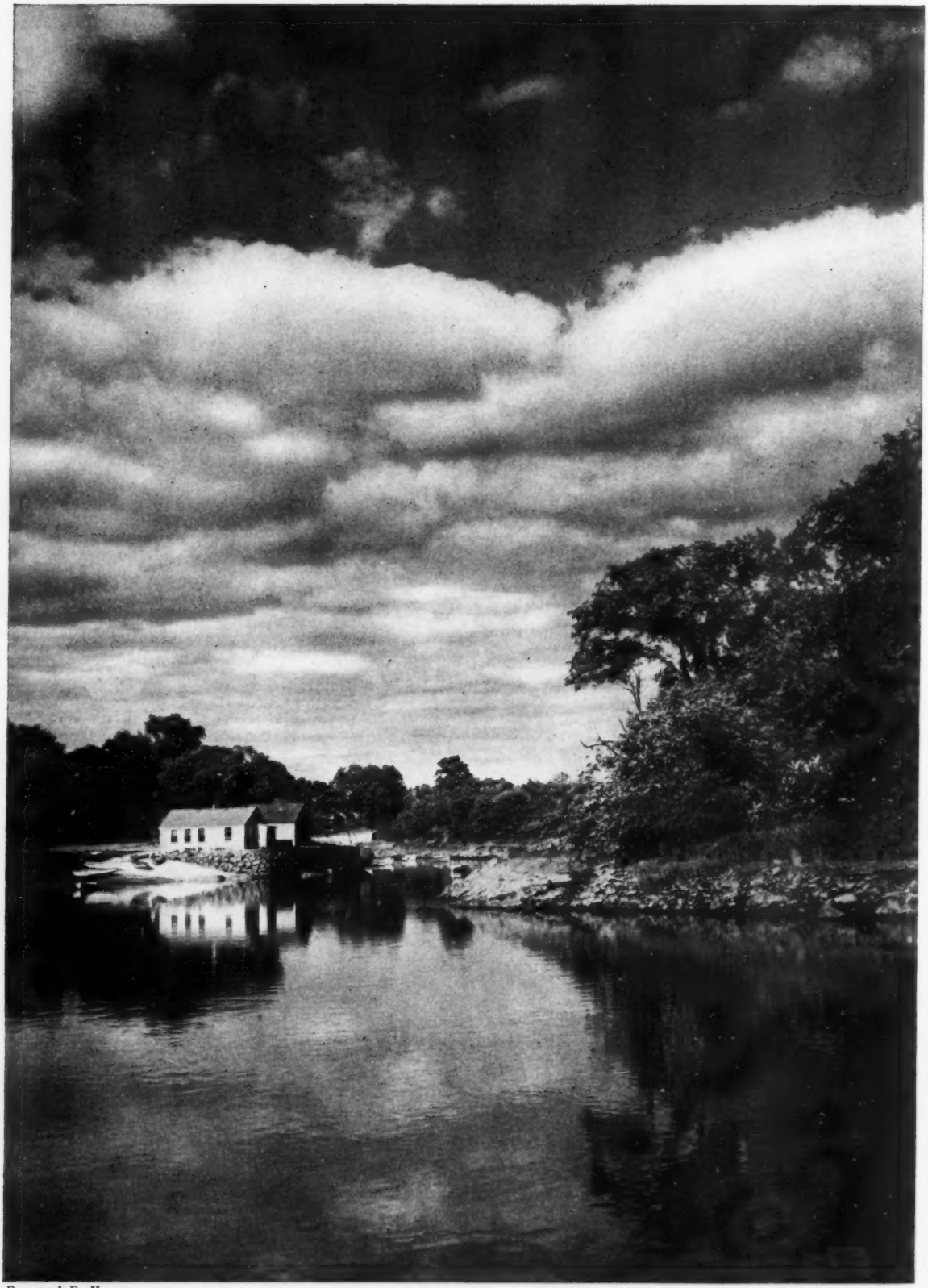


Raymond E. Hanson

"Then, if ever, come perfect days . . ."

—James Russell Lowell

THE
TECHNOLOGY
REVIEW

Vol. 53, No. 8 June, 1951

The Trend of Affairs

Half Starved

SEMISTARVATION has occurred widely, both chronologically and geographically, throughout the history of the world. Famines have been caused not only by wars, but also by drastic crop failures, or even by chronic inability of the economy in a given region to support the population.

When first deprived of sufficient food, the human being suffers severe discomfort and disabling weakness. Why, then, have large numbers of people been able to survive for extended periods of time on famine rations? Why have such half-starved populations been able to pursue fairly normal activities, including muscular work? A firm answer to these previously baffling questions has now come from pioneer intensive studies of semistarvation, with human volunteers as subjects, conducted at the University of Minnesota. The 30-odd volunteers were intelligent, co-operative men. They were kept under continuous observation, and were subjected to exhaustive biochemical tests and clinical examinations. Their food intake was regulated exactly. Because of this thorough control of the experiment, the effects of semistarvation upon the human being were delineated much more clearly than had previously been possible on the basis of random observations of actual famine victims.

The subjects at the University of Minnesota ate a diet simulating famine rations in northern Europe. This regimen caused a loss of some quarter of the body weight in the course of six months, along with the appearance of other classical signs and symptoms of semistarvation. But, at the same time, the volunteers effected several marked physiological adjustments, which tended to bring them toward equilibrium with their reduced food consumption, by diminishing their need for energy derived from food.

The energy demanded for muscular activity was markedly curtailed. Part of this curtailment was traced to voluntary elimination of much of the needless, unproductive muscular activity that the human being usually indulges in quite freely, and also spontaneous performance of necessary acts in ways that minimized expenditure (such as climbing stairs one step at a time). An additional saving in energy used for muscular work – and this observation is indeed surprising – resulted from the fact that the energy spent to accomplish standardized muscular tasks decreased in direct proportion to loss of body weight.

Another reduction in energy needs of the semistarved men resulted from decreases in basal metabolic rate. This rate measures the energy used to maintain the body at complete rest, with no overt muscular activity whatsoever. Part of this energy saving had been expected because of the diminished body mass resulting from emaciation. But an unexpected energy saving in this category was traced to a definite decrease in the metabolic intensity of the remaining body tissues.

Finally, the energy used by the heart was reduced, as the work done by this organ dropped to half the normal level. The resultant energy saving was considerable; the heart is a sizable muscle group that is constantly at work, and claims a substantial proportion of total energy supplied.

As a result of these marked spontaneous decreases in energy requirements, the University of Minnesota subjects, like many actual famine victims, were able to remain active and to perform a variety of tasks. This research explains quantitatively how their physiological adjustments to a deficient food intake were made. Thus is afforded greatly improved understanding of one facet of the recognized resiliency of the human organism in adapting to adverse conditions.

Blowdown Tunnel

For many years the Institute's Department of Aeronautical Engineering has been able to conduct effective research on aircraft operating at subsonic velocities through facilities provided by the Wright Brothers Wind Tunnel and smaller tunnels available for educational purposes. Since the end of World War II, completion of the Naval Supersonic Laboratory and expansion of the facilities of the Gas Turbine Laboratory have made possible research at supersonic velocities. Facilities in the transonic range, where velocities of from 600 to 1,000 miles per hour are encountered, have not been so well provided, but this omission is now being rectified. A transonic wind tunnel is under construction at Technology to facilitate research and instruction in aerodynamics in this speed range. The design and construction of the new tunnel are under the direction of Joseph Bicknell,'34, Associate Professor of Aeronautical Engineering, assisted by Harold P. Hilberg, a research associate in the Department of Aeronautical Engineering.

Supersonic and transonic tunnels may be either continuous or intermittent in operation. The continuous type provides a steady flow of air within its range of flow, but this is accomplished by motors and blowers of large power requiring high initial and operating cost. The intermittent, or blowdown, type of tunnel provides flow for a short period – usually between 15 seconds and five minutes – and requires suitable recording equipment to obtain test data rapidly during the short operating period. In one type of intermittent tunnel, the test chamber is connected to a large tank which is evacuated by pumps. A valve connecting the test chamber with the tank is then opened and the air rushing into the tank through the tunnel provides transonic air flow for the operating period. As long as the pressure in the tank is below a certain value, its variation is not felt in the test section; hence, test section Mach number, true speed, and density automatically remain constant.

In the other type of intermittent tunnel, the air is compressed in the tank and exhausts to the atmosphere during the blowdown. The test section conditions would vary unless a regulating valve or throttle were inserted between the tank and the tunnel to keep a constant pressure at the tunnel as the tank pressure decreases. As the air expands in the tank, its temperature drops so that some sort of heat supply must be used to maintain constant temperature during blowdown. Using the tank compressed, instead of evacuated, roughly doubles the Reynolds number, or the effective scale of the model, through higher density of air in the test section. Current designs favor this type of operation.

With a suitable tank (which represents a large part of the cost of an intermittent tunnel) already available in the Wright Brothers Wind Tunnel, design work was predicated on its use as the storage tank. The test section should be large enough for aeroelastic investigation and for airplane design evaluation and research. A section of about three square feet in area is felt adequate, and, with the size of tank available there is a running time of 15 seconds. Allowing five seconds for the pressure-regulating system to come to equilibrium, 10 seconds remain for testing. With proper recording equipment, the same amount of data can be obtained in this period as is obtained in 15 minutes in the Wright Brothers Wind Tunnel.

During the new transonic wind tunnel's operation, air in the Wright Brothers Wind Tunnel will be compressed to approximately 30 pounds per square inch gauge, using the compressor originally installed to compress and evacuate the tunnel. Compression between blowdowns will take approximately one hour. The air is dried as it is compressed to prevent condensation as it expands through the transonic tunnel.

The test section is octagonal, 22 inches flat to flat. A model support system varies the attitude of the model continuously during blowdown; and the forces and moments are measured on a "sting" balance with resistance strain gauges, and recorded on oscillographs. The air from the tunnel exhausts in a sound-treated vertical stack.

It is expected that the new facility will be self-supporting as a result of research and design evaluation testing for the government or industry, and that the tunnel will be put into operation late this fall.

Hydraulic Valves Improved

The satisfactory performance of many control systems often requires servomechanisms of considerably greater accuracy and speed of response than have been previously available. For example, the acceleration requirements are sufficiently severe in certain instances so that no existing electric motors can be used, and the chance of developing satisfactory motors seems rather remote. Accordingly, the Dynamic Analysis and Control Laboratory, under the direction of Professor John A. Hrones, '34, of the Department of Mechanical Engineering, has conducted a program of research on, and development of, flow valve-controlled hydraulic servomechanisms. This program has resulted in the development of a number of high-performance servomechanisms and in the accumulation of a store of information on hydraulic control, much of which has not been easily available and some of which is believed to be new.

In designing a hydraulic control valve for servosystems or similar applications, it is important to know the axial force necessary to operate the piston. This force has three principal components: inertial force, which is easily calculable; friction, which can be approximately estimated; and the force produced by the flow of liquid through the metering orifices of the valve, for which virtually no data are available. In some cases, a fourth force which is proportional to the rate of change of flow through the valve may be important since it may cause instability and self-oscillation in the valve. These forces were studied mathematically and experimentally for a four-way type of valve by Shih-Ying Lee, '43, and John F. Blackburn, both of the Division of Industrial Cooperation, in the hydraulics section of the Dynamic Analysis and Control Laboratory.

The analysis of the steady-state forces led to a new type of valve design in which the square land chamber configuration is replaced by a chamber piston shaped somewhat like a turbine bucket with the

Trend in Occupational Medicine

M.I.T. Photo

Believing in the old adage that "an ounce of prevention is worth a pound of cure," the Institute's Medical Department has placed considerable emphasis, throughout the years, on keeping students, Faculty, and staff members in good health, and on eliminating health hazards of all kinds as much as possible. With the Institute's rapidly expanding research activities, the problems of analysis and correction of hazards caused by toxic chemical, radiological, or dust particles, as well as the more subtle problems of unusual occupational stress, such as noise and lighting, began to assume sufficient importance as to warrant special precautionary measures. As a result, the Occupational Medical Service was established on a part-time basis in 1947 at the request of Dr. Dana L. Farnsworth, M.I.T. Medical Director, and was expanded to full-time service in 1949 with the appointment of Dr. Harriet L. Hardy, Assistant Medical Director in charge of Occupational Medical Service.

In keeping with the trend to enhance the preventative rather than the corrective aspects of modern medicine, the work of this Service has been steadily expanded, and new laboratory facilities have just been completed on the second floor of Homberg Infirmary. Dangers to workers associated with disposal of radioactive and unusually toxic waste materials are studied, and safeguards recommended by the Occupational Medical Service working in consultation with the Institute's safety engineer. The illustration shows Dr. Ivan D. Frantz, Jr., Radiological Medical Officer, and Dr. Harriet L. Hardy, Director of Occupational Medical Service, studying a chest x-ray.

Although primarily intended to detect industrial hazards and recommend means for their elimination, an important and logical activity of the Occupational Medical Service is to provide instruction for undergraduate and graduate students so that they may learn what is necessary for protection from unnecessary occupational hazards. To date, several informal seminars have been held at the request of various members of the Faculty, resulting in sessions in the Departments of Chemistry, Metallurgy, and Sanitary Engineering. It is planned to offer a term course in occupational hygiene in the Graduate School which will provide sufficient background and technical data to allow a student of engineering to carry out consultation service in industry.

sleeve cut out to form an extension of the downstream chamber. This design gives cancellation of the flow forces within the limits of manufacturing imperfections and is but slightly more difficult to make than the conventional valve.

In servomechanisms, it is common practice for hydraulic valves to be operated by electric torque motors driven by vacuum tubes. Because tubes are used as the control elements, the power to the torque motors is limited to a few watts, and this restriction, plus the inherent design limitations of electromagnetic devices and the large force required to stroke a square land piston, have, in the past, limited the outputs of single-stage valves to perhaps one kilowatt; higher outputs were controlled by using two or more valves in cascade. The program of the Dynamic Analysis and Control Laboratory has resulted in the development of a four-way hydraulic valve which operates satisfactorily at high speeds, free from oscillation, and with moving parts inherently balanced. The new valve design extends the speed and precision of performance possible with servomechanisms.

Major contributions to this development were made by Raymond D. Atchley, a research assistant in the Department of Electrical Engineering, and Albert C. Hall, '37, former Director of the Dynamic Analysis and Control Laboratory. The work was supported by the Naval Bureau of Ordnance.

All Men Are Unequal

BOTH in research and industry, the problem of measurement in food flavor evaluation has completely mystified and baffled the devotees of mechanism. It would be desirable to place measurements in this field on a truly objective basis through use of physical measuring techniques instead of depending upon the human being as a measuring instrument, especially since subjective evaluations by two different persons are never exactly alike. At first blush, it may seem strange that suitable measuring techniques have not been developed. But until more information about the senses of taste and smell becomes available, the human being will continue not only supreme but also unique as the instrument with which taste and smell are evaluated.

Why is the measurement of taste and smell, and therefore research on the human being as a measuring instrument, important? If foods do not taste and smell good, they will not be eaten. If foods are not eaten, they can contribute nothing to our well-being. In spite of the influence of advertising, palatability and, to an important extent, food flavor are the heart of competition in the food industry. Consequently, if foods, as produced by the food industry, do not taste and smell good, they will not be purchased. The food industry would die of starvation and, of necessity, all of us would revert to farming, hunting,

and fishing. The human being as a measuring instrument of taste and smell is, therefore, a key to our general enjoyment of living and to the continued success of our food industry.

During the past four years in the Department of Food Technology, Ernest E. Lockhart, '34, Assistant Professor of Food Chemistry, has been studying the human being – his similarities to and differences from other human beings, his sensitivities, the relationship of physiological and environmental factors to the accuracy and dependability of his responses to test stimuli in the form of pure chemical compounds and composites, such as foods – in order to determine his potentiality and usefulness in handling taste and smell problems that are ever present in the food industry. In the field of human instrumentation, just as in other fields, instruments must be understood and calibrated. In the past, understanding has been relatively simple but calibration was difficult. Because of new conceptions of experimental design and recent developments in statistical analysis, objective treatment of subjective reaction and response is possible. The human instrument can be calibrated with less difficulty and with greater assurance of adequate performance now than was possible before.

All human beings are different. Although any one individual may serve as an instrument for determining differences in food products or changes that may have occurred during processing or storage, it would be unwise to predict general public reaction or consumer acceptance on the basis of one judgment. Test situations arise in which many individuals are used. Responses may be equally divided, unequally divided, or completely in agreement. Here, again, proper use of experimental design and statistical analysis provides meaningful results interpretable in terms of expected consumer reaction. But until we know more about the senses of taste and smell, it will be impossible to devise instruments to evaluate such factors on a quantitative basis, and the human being will remain as the unique, if qualitative and subjective, instrument available for evaluating the senses of taste and smell.

Out of Joint

Sighing, snoring, hiccuping, yawning, and joint cracking are virtually universal facets of human behavior. Nevertheless, the mechanisms underlying these acts are not well understood, and what useful function they serve, if any, is still more obscure. Sighing, snoring, hiccuping, and yawning are classified in physiology textbooks as "modified respiratory movements." Yawning involves, in addition to the respiratory act, a stretching of certain muscles of the head and neck. Yawning is frequently accompanied by what we know as stretching—the hyperextension of arms, legs, or other parts of the body. Yawning and stretching in turn often involve the remaining obscure aspect of human behavior, namely joint cracking. In some persons the jaw may crack during a good, wide yawn; in others, stretching of the arms or legs may cause joints in these members to crack. Besides stretching, the flexing of a joint that has been at rest for some time often causes cracking.

Despite the ubiquity of joint cracking, the nature and significance of this phenomenon have not been explained, except on largely inferential grounds. A recently published discussion of the subject suggests that cracking may be caused by fibrositis, which is inflammatory enlargement of fibrous tissue in joints. Either hyperextension, or flexion, of a joint stretches its fibrous tissue. Therefore it is suggested that when fibrositis is present, such stretching produces the distinct noise of joint cracking. Although pronounced fibrositis is associated with chronic rheumatism, milder degrees of the condition have been characterized as "the most common ailment to which human flesh is heir." This concept, and the proposal that fibrositis is the cause of cracking, together harmonize with the recognized ubiquity of cracking joints.

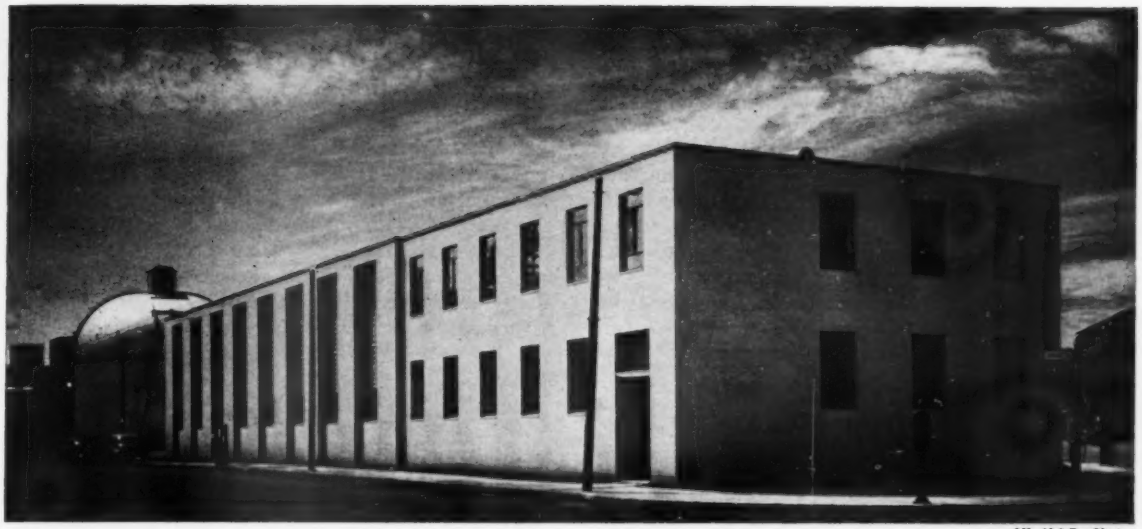
Two environmental conditions are believed to predispose toward the cracking of joints. One of these conditions is low ambient temperature. This statement will not surprise those who possess cracking joints, as joint cracking is usually acknowledged to occur more frequently in cold weather. But the other major predisposing factor stated is somewhat startling; this is ionized air, as existing during electrical storms. If you hear a faint mysterious noise during the season when electrical storms prevail, it may be distant thunder, or it may be a concerted cracking of your neighbors' joints.

Atmospheric Tides

An investigation of the dynamical tides in the earth's atmosphere has recently been completed at the Computation Laboratory of M.I.T. by Luigi G. Jacchia, a research associate in Electrical Engineering, and Zdenek Kopal, Associate Professor of Computational Analysis, under the sponsorship of the National Advisory Committee for Aeronautics, with the aid of M.I.T. large-scale computing machines.

On the earth's surface, the tide-producing force of the moon exceeds that of the sun by a factor of 2.2, and the observed amplitudes of the lunar and solar components in ocean tides are approximately in that ratio. The situation is radically different in the case of tides of the atmosphere, where the solar component exceeds the lunar by a factor of 45. This fact can be explained by resonance; that is, one of the free periods of oscillation of the atmosphere, as a whole, is so close to 12 hours that the pressure oscillations with the solar period are greatly enhanced. The proximity to resonance makes it possible to use the pressure tides as a tool for investigating the distribution of temperature in the upper atmosphere (between 40 and 100 kilometers) which is almost inaccessible to any direct kind of measurement. The investigation at Technology has resulted in establishing a standard temperature profile which agrees with the direct temperature measurements in the lower atmosphere, is consistent with other indirect evidence pertaining to the upper atmosphere, and accounts quantitatively for the observed atmospheric tides.

A continuation of this investigation, under the sponsorship of the National Advisory Committee for Aeronautics, is being planned in order to learn more about the dynamics of the terrestrial atmosphere.



All M.I.T. Photos

The New Hydrodynamics Laboratory

First Unit to be Completed under the Development Program Brings to M.I.T. New Training and Research Facilities for Studying the Mechanics of Liquid Flow

By ARTHUR T. IPPEN

THE new and extensive laboratory, to be known as the Hydrodynamics Laboratory, is the first to be completed of the projects envisioned as essential under the recent successful drive for M.I.T.'s expansion. It brings to the Institute facilities long considered necessary for basic training as well as for research in hydrodynamics. A new laboratory for the experimental study of the mechanics of liquid flow, distinct from the usual facilities provided for undergraduate instruction, was proposed for M.I.T. even before World War I, as plans which Professor Emeritus George E. Russell, '00, of the Department of Civil and Sanitary Engineering, still possesses will prove. However, it was not until after World War II that new plans were drawn up, which culminated in the erection, during the years 1949 and 1950, of the new Hydrodynamics Laboratory which will be administered by the Department of Civil and Sanitary Engineering.

Purpose of the Laboratory. In line with the emphasis which research is given in the over-all educational process at M.I.T., the laboratory is planned primarily for the pursuit of fundamental studies in the many branches of hydrodynamics. Often such studies seem somewhat removed from the immediate and specific problems faced by the practicing engineer. Frequently they are of the type for which industrial and governmental laboratories do not usually find time, because of the pressure of more immediate and specific production and design problems, even though the desired information has great practical value. The integration and co-ordination of new knowledge into generally applicable principles, therefore, seems to fall primarily into the domain of the research laboratories at institutions such as M.I.T. Broadly speaking, the new Hydrodynamics Laboratory will be devoted to such research objectives.

More specifically, studies in the laboratory will be concerned with fundamental problems on the nature of surface resistance, internal flow patterns, turbulent flow, and associated mixing processes; they will deal with the formation of surface waves and of surface profiles in open-channel flow as a function of geometric boundary conditions, with the forces exerted on immersed bodies, producing transport of sediments in streams, and the transfer of matter and properties in industrial processes.

Studies in these fields of fluid technology again often call for the development of new measuring techniques and instruments. The laboratory will thus provide a training center for staff members drawn from varied professional backgrounds. The resulting interchange of ideas, derived from the various engineering sciences, will give a more concerted and organic approach to a problem, of benefit not only toward its solution but also to a more universal professional experience of the staff.

Planning the Building. The M.I.T. Hydrodynamics Laboratory was planned for a maximum of useful

floor space with ample headroom and with a minimum of built-in features. The location of the building was determined primarily by the desirability of adequate length for flumes and experimental piping and with a view toward future expansion. In order to keep it in the vicinity of the educational plant and other laboratory facilities east of Massachusetts Avenue, the laboratory was located along Vassar Street near Main Street – the only space available. Adequate water supply was afforded by large water-storage tanks with water circulation provided by a central pumping system. Such a system is independent of natural streams and at all times provides a flexible supply of clean water under readily controlled pressures.

The basic features of the building were further governed by the local subsoil conditions, which made it necessary to erect the building on a solid reinforced concrete mat with an average thickness of six feet to avoid differential settling. All storage tanks and the circulating pipes were thus fixed in elevation and had to be planned for above this concrete mat which forms the basement floor.

The specifications provided for unobstructed floor space for laboratory use in a hall more than 100 feet long and 50 feet wide and of double-story height – with additional space for offices, shops, darkrooms, lecture room, drafting room, and general service rooms of single-story height. Concrete water-storage tanks of more than 15,000 cubic foot capacity with circulating facilities, as well as a Ship Model Towing Tank for the Department of Naval Architecture and Marine Engineering, were to be provided for in the basement area.

The architect, Robert C. Dean, '26, assisted by T. Thomas Amirian, '32, of Perry, Shaw and Hepburn, Kehoe and Dean of Boston, solved his assignment by adopting an essentially rectangular floor plan 59 feet wide by 188 feet long, oriented along the lot line parallel to Vassar Street and extending west from Main Street. The main hall of the experimental portion is 120 feet long and occupies the western part of the building. It will be devoted primarily to research facilities of a nonpermanent nature. The basement area below this hall has the Ship Model Towing Tank extending over the full length along the south, or Vassar Street side, and the main water-storage tank along the north side. The piping circuit, consisting of galvanized pipe 18 inches in diameter for the distribution of flow to all parts of the hall above, is arranged overhead, so that except for the two tanks the basement floor area also remains available for laboratory experiments.

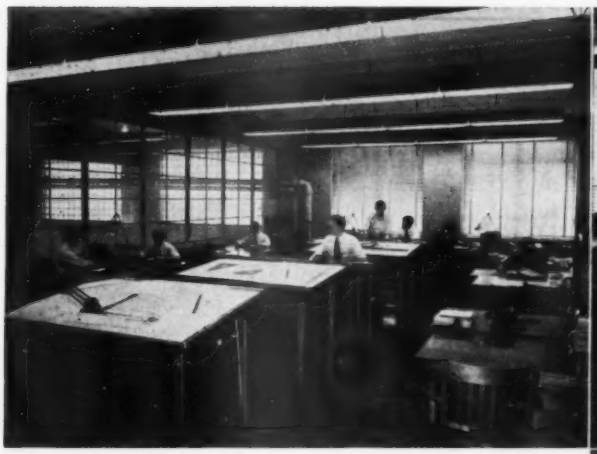
Main hall of research laboratory looking east toward two-story section with shop and demonstration laboratory on main floor, and drafting room, lecture room, and offices above.

The north end of the building contains all the other utility, lecture, and office rooms. In the basement along the outside walls are the transformer room, the main switchboards, and general service space, as well as a locker room and two well-furnished darkrooms. An additional water-storage tank 42 feet in length serves a laboratory room on the first floor which will contain smaller demonstration equipment and testing facilities for instruction purposes. This room on the first floor is accessible directly from the stair well at the southeast corner and occupies approximately half of the single-story space; the other half is given over to an extensive shop with stock room along the north wall and to two smaller rooms for electronic work and instrument storage. The lecture room on the second floor accommodates 60 persons and provides for classroom and computational work in connection with laboratory experiments carried on by students. A series of offices for the staff of the Hydrodynamics Laboratory and of the Ship Model Towing Tank extends along the outside wall portions, while a large drafting room accommodates assistants and graduate students engaged on research projects. The drafting room overlooks the main hall of the building and was therefore furnished with a window extending over the entire length of the adjoining wall. For special occasions the drafting room may be connected to the parallel lecture room by removing the transite wall partition, thus providing a greatly enlarged lecture hall. From this description of the general space distribution in the building, the close correlation of all research activities with the educational process to be served simultaneously is again evident.

During the limited period in which the building has been occupied, the soundness and simplicity of the floor plan have already been amply demonstrated. The bright and varied colors utilized for all the walls in the building provide a pleasant interior for all working areas. The exterior treatment of the building is in keeping with similar structures at M.I.T.; it is simple and without pretense. Yellow brick walls conceal the steel skeleton and reinforced concrete construction; the only outstanding feature consists of the high glass-brick windows lighting the main laboratory hall along its south side and extending over the two-story height.

Future extension of the building westward, as well as the addition of two stories, was given consideration in the planning and in the dimensioning of the supporting structure. Of interest to structural men may be the fact that the main hall is spanned over the 60-foot width by the largest rolled I sections, 3 feet high, and spaced 15 feet center to center.

Built-in Facilities for Experimental Work. To keep the floor area as flexible as possible only a minimum of fixed equipment was incorporated into the build-



In clockwise order, these illustrations give an indication of the spaciousness and completeness of the drafting room and office for research assistants, the lecture room for teaching and laboratory computation, and the shop and stock room, with which the Hydrodynamics Laboratory is provided.

ing. This includes, of course, adequate water-circulating and storage facilities and electric power lines as primary requirements. The electric system has a capacity of 600 kilovolt-amperes, and adequate feeder lines lead to numerous junction boxes strategically placed throughout the laboratory. A large rectangular loop of galvanized steel pipe 18 inches in diameter was constructed to bring the maximum flow of 15,000 gallons per minute from the circulating pumps as near as possible to any portion of the main hall, shown in the illustration on the opposite page.

This 18-inch distribution pipe, furnished by the Crane Company, Chicago, was placed overhead in the basement to be connected to the first floor space through numerous 30-inch square openings in the concrete floor, which are normally tightly closed with special steel covers. Such openings are also arranged directly over the large water-storage tanks providing ready access, but when not in use keeping dirt and surface drainage from the tanks. A separate system was incorporated into the first floor to take care of drainage. With all water passages consisting of galvanized piping and all light excluded from the storage tanks, the water is kept clean for long periods of time. This is an important objective in view of the significant part which photography plays in practically all experimental problems.

The L-shaped main storage tank extends along the major portion of the north wall in the basement. It has a width of 8.5 feet except at one end in the northwest corner of the basement which has a section expanded to approximately 24 by 20 feet. The storage capacity is in excess of 11,000 cubic feet for this tank alone, which is augmented by the storage capacity of another tank 42 feet by 8.5 feet situated along the south wall, below the demonstration laboratory. This tank, holding 3,600 cubic feet of water, may be used separately or in conjunction with the main tank to which it is connected by a gravity return line of 18-inch galvanized pipe. Small tanks for the volumetric measurement of flow rates, up to the maximum capacity of the pumps, are arranged at the east end of the main reservoir. They have capacities of 300 and 1,500 cubic feet. Meters employed on experimental units, as well as the two large Venturi meters, 18 inches by 10 inches, in the rectangular loop of the supply pipe (which were furnished by Builders-Providence, Inc. of Providence, R.I.) may be accurately calibrated in place against the primary standard of volume. The west end of the main reservoir is used as the suction chamber for the main circulating pumps, donated by the Ingersoll-Rand Company of New York. For flexibility in use, three pumps are employed; their rated capacities are 8,000, 4,000, and 3,000 gallons per minute, respectively, at the rated head of approximately 40 feet. These pumps may be used in parallel, or separately, to give any discharge desired up to a flow of 15,000 gallons per minute, or even greater, if the head required is lower. The line pressures may be adjusted on the discharge side of the pumps by motor-operated valves which are controlled from the testing floor. The main supply line may also be split by means of gate valves into two or three separate circuits with capacities corresponding to combinations of two pumps, or to those of the individual pumps. All pumps operate with submerged suction eliminating priming, and the entrance conditions at the intakes in the large reservoir are such as to insure steady and uniform operation. This is quite important for the prosecution of all experimental work and reduces the need for a costly

arrangement of maintaining constant head by means of special overflow tanks.

In addition to the large circulating pumps, a number of smaller and readily movable pumps are available for integration into the experimental units themselves wherever desired. To supply power for this purpose, as well as for other machinery to be employed, 220-volt electric power lines are provided with numerous junction boxes along the north wall of the main hall, along the center of the basement, and along the south wall of the demonstration laboratory. The capacities of these power lines are 200 horsepower for the basement and 100 horsepower each for the lines on the first floor. The shop area is served by a central bus duct for all machine tools. The main hall is furnished with an electric traveling hoist of the monorail type and of two-ton capacity. It is used to transport equipment normally used within the hall and to the basement storage space to which access is had through large steel hatches.

Considerable attention was given to the layout of the photographic darkrooms. Two rooms separated by a doorless labyrinth passage were finally provided; one for printing and one for developing, both with ample stainless steel sinks and built-in furniture. The photographic equipment to be utilized naturally includes cameras for different purposes and special lighting facilities for high-speed photography.

Research Facilities and Demonstration Equipment. A large floor area of over 6,700 square feet is available in the main hall for almost any kind of activity in experimental hydrodynamics, with an additional area of more than 4,400 square feet in the basement, exclusive of the tanks, and of 1,500 square feet in the demonstration laboratory. This floor space will be devoted to equipment and experimental facilities for educational and research purposes with as much diversification in the field as feasible. Wherever possible, use of relatively small units will be the aim. To give an idea of the type of work planned and carried on at the present time, a short résumé of the equipment contemplated, or presently available, may be given, calling attention at the same time to the illustrations accompanying this article.

In the demonstration laboratory a number of small units will be used to explain the major problems of hydraulic design of closed and open conduits and the fundamental characteristics of pumps and turbines. The S. Morgan Smith Company provided an adjustable blade propeller pump, 12 inches in diameter, as well as an adjustable blade Kaplan turbine, 10 inches in diameter, complete with dynamometers. The setting of these is designed to permit performance tests for both units under a wide range of conditions and with accurate measurements of discharge, head, speed, and torque. These units promise to be outstanding for instruction purposes; small enough to be readily operated by students, yet large enough to give performance data in line with those of modern turbines and pumps of any prototype size.

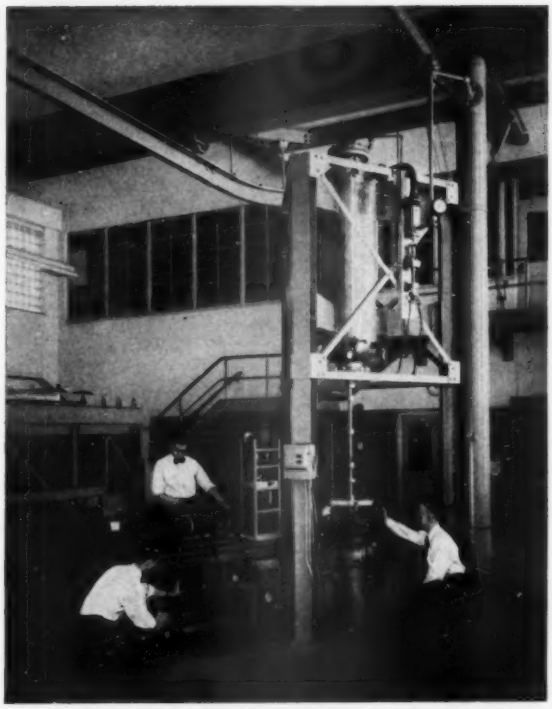
Flow phenomena in open channels, flow over weirs and dams, flow from sluices, the hydraulic jump and its modifications in modern stilling basins at the toe of spillways, will be studied in glass-walled flumes readily adaptable to these various problems. A smaller glass-wall tank is used to show the basic flow patterns of density currents, as they are found in river estuaries (where the tides periodically move a salt-water wedge upstream and under the fresh water coming down the river) or in large reservoirs (where the entering silt-laden stream moves along the bottom under the standing waters). The sanitary engineer is faced with similar problems with outfalls into rivers or lakes and in the design of settling tanks. The field of water power is included not only with studies on turbine performance but a basic hydraulic model will also demonstrate problems in the design of surge tanks and in the governing of turbines.

An electronic analog computer has been utilized with great success for such problems and is primarily employed for research on unsteady flow, where the solution of the basic equations by ordinary means is too time-consuming and precludes extensive exploration of wider applications.

Additional equipment for the demonstration laboratory is to include apparatus to determine two-dimensional streamline patterns for flow around immersed bodies and through channels of various forms. Diverse techniques employing the Hele-Shaw

This lucite model of a spillway, which is set in a glass-walled flume, is used in teaching the flow of water over a dam. A hydraulic jump is formed at the toe of the dam.

Standing wave pattern caused by stream entering a channel contraction at velocity higher than wave velocity. Shock waves in supersonic gas flow produce analogous patterns.



The pilot model of the unsteady flow water tunnel with automatic pressure controls to produce accelerated motion through the pipe connecting the upper tank with lower receiver.

Transient pressure and flow phenomena in penstocks and surge chambers in hydropower plants are studied by means of electronic analog computers.

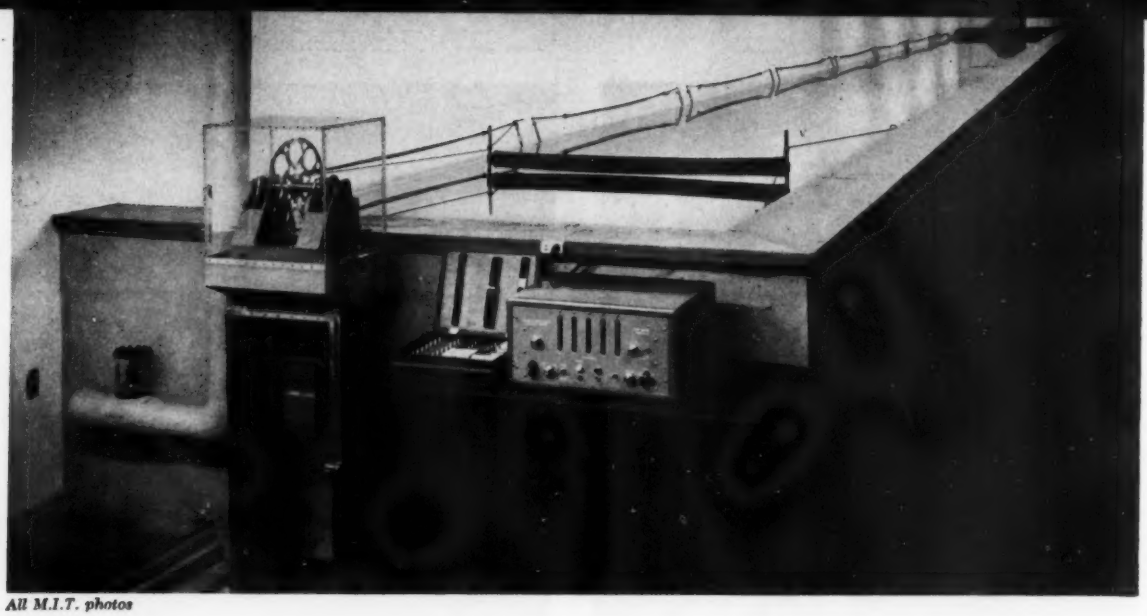
method, bentonite suspensions with polarized light, or electrical analogies are available for such studies of potential motion. Provisions will also be made for installations for resistance measurements in closed conduits of varying roughness with elbows, contracting sections, diffusers, and other objects of technical interest.

Thus the equipment in the demonstration laboratory is planned primarily to transmit to the student visually – and by systematic test – the most important aspects of the mechanics of liquid flow with particular reference to engineering problems. The experimental units in the main hall are devoted principally to the solution of specific research assignments, most of which are sponsored by governmental agencies at present. All problems are in the realm of fundamental investigations, rather than in that of special development for particular engineering problems. They are therefore well adapted to our aims of graduate training, and the staff on the sponsored projects is comprised primarily of graduate students. In addition, some of this equipment lends itself to investigations beyond the scope of the immediate assignment and is available for graduate thesis work for full-time students.

The Army Air Force has supported investigations on the analogy between the flow of water at velocities higher than the wave velocity for given depths, and the supersonic flow of air through conduits or past wing sections of airplanes. This work is done by means of a channel, more than 40 feet in length, with a glass bottom. The channel can be tilted up to 10 per cent

(*Continued on page 429*)

Equipment for conducting aeration experiments provides for the transfer of oxygen to deaerated water in the tall lucite column, through which air or oxygen is rising in small bubbles. A mercury drop electrode system with recorder gives a continuous indication of oxygen content of the water.



All M.I.T. photos

The Ship Model Towing Tank

Precision Tests on Models As Long As Six Feet Can Be Made in the Institute's Towing Tank

By MARTIN A. ABKOWITZ

THE advent of the building of the new Ship Model Towing Tank at M.I.T. brought to realization a long-time desire of the Department of Naval Architecture and Marine Engineering for a research and instruction facility in the field of hydrodynamics of ship design. The towing tank is located in, and constitutes a part of, the new Hydrodynamics Laboratory and was constructed as a project of the M.I.T. Development Program.

Purpose of Ship Model Tests. Although a towing tank may be used for a variety of types of hydrodynamic research, its principal purpose, and therefore the basis of its design, is to make possible the prediction of the power requirements of the full-size ship from tests carried out on a geometrically similar model. A fairly accurate estimation of horsepower requirement of a ship design must be made very early in the planning stage in order that the necessary space and weight may be allocated for machinery and fuel. At present, the estimation of the power necessary to drive a ship of a given design at a certain speed can be obtained either from tests on a model or from published results of model or full-scale trial tests of ships with similar general characteristics. Properly performed, tests on models will yield much more accurate estimates. Ship-model tests are also extremely useful in comparing the relative performance and efficiency of several designs.

The Institute had a need, therefore, to construct a ship model towing tank of limited size such that the results of model tests conducted in the tank would be of sufficient precision to assure an accurate extrapolation of test data to the full size prototype.

Description of Towing Tank. The towing tank is 108 feet long, 8 feet 7 inches wide, and 4 feet deep. The water level in the tank may be set at any desired level up to 4 feet to simulate a prototype operating in shallow water. The four-foot water depth is used to simulate deep water operation of the full size ship. The size of the tank limits the length of the models which may be effectively used to a length of between four and six feet. The finer the shape of the ship, the larger is the length of model permitted. The limitation on model size is necessitated by wall and bottom effects which, for a given size of tank, become significant if the ship model which is to be tested is too large.

In order to observe and photograph the submerged portion of the model while in operation, a glass wall 30 feet long and running the full depth of the tank is located just beyond the mid-length of the tank where the model maintains a constant speed. The size and geometry of waves produced by a wave generator may be observed through the glass wall during the course of tests simulating rough water. In addition, the existence of this glass wall makes the towing tank suitable for air-water entry research.

The tank bottom is level in order to carry out shallow water conditions. Drainage is provided by sloping gutters along the side.

Threaded and plugged brass anchor pieces are embedded into the concrete bottom of the tank every seven and a half feet along the length and three feet on each side of the center line. These anchor pieces provide a ready means of securing auxiliary apparatus for special types of research, such as walls within the tank to simulate a ship operating in a canal.

Wave dissipators are installed along the walls on each side and at each end of the tank in order to destroy surface waves rapidly and to calm the water surface after each run of the model. The wave dissipators consist of long cylindrical metal tubes placed horizontally and partially submerged so that the upper portion of the circumference just penetrates through the water surface. They can be adjusted to any water level and can quickly be lowered to the bottom of the tank when testing ship models in waves.

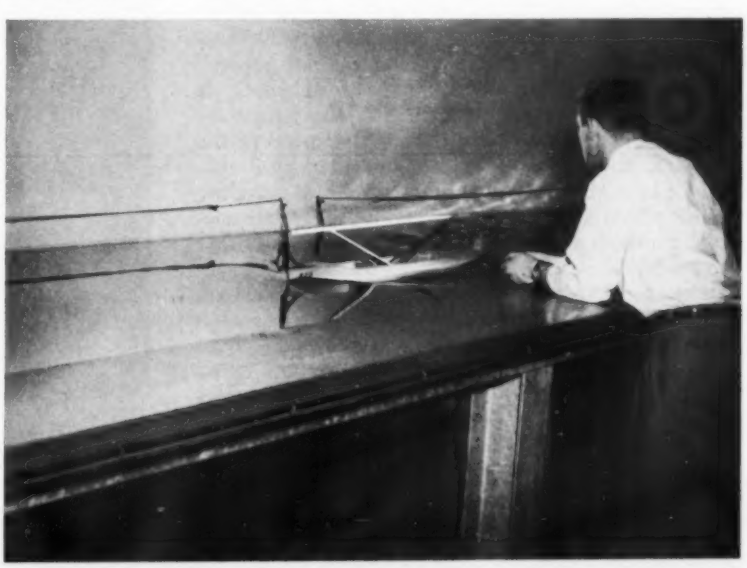
Measuring the Towing Force. The dynamometer used to measure the resistance force and speed of the model uses falling weights to provide the towing force, and is therefore known as a "gravity type." This type of dynamometer was constructed to obtain the necessary precision in the measurements of force and speed of a small model. In addition, when towing the model in waves, the gravity-type dynamometer simulates the condition of essentially constant propeller thrust of the prototype, and for both model and prototype the speed in waves varies in an oscillatory fashion.

The precision of the instrumentation provides measurement of the towing force to within 10^{-4} pound, and measurement of the speed to 10^{-3} knot (one knot equals 1.689 feet per second). The accuracy of measurement of the speed and of the towing force is about one-tenth of one per cent. The sensitivity necessary in measuring the speed and resistance of the model may be inferred from the fact that a 500-foot ship of a certain design, moving at 18 knots, has 121,000 pounds resistance, while a five-foot model, simulating the prototype, requires a towing force of only 0.16 pound.

Two single-grooved pulleys, one mounted along the center line at each end of the tank, support a continuous cord under five pounds' tension. A towing bracket connects the ship model to the cord. The torque on the pulleys necessary to tow the model is provided by two weight pans connected to one of the pulleys by means of cords wound into a threaded groove on the shaft of the pulley. The two weight pans hang from the shaft diametrically opposite each other and are connected to each other by the cords wound around the pulley shaft. The unbalanced torque (and therefore the towing force) is provided by removing weights from one pan and placing them into the other pan. As the model travels along the tank, one weight pan moves vertically downward while the other rises. This method produces the desired torque without altering the load on the pulley. Since the load on the pulley bearings is essentially constant for all runs, the pulley friction is a function only of speed. The diameter of the pulley is 10 times that of the shaft so that the towing force is one-tenth the difference in weights on the two pans minus a calibrated friction force which varies with speed, and the model travels 10 times the distance which the weight pans move. The friction of the entire towing assembly (that is, pulleys, cord, weight pans, and weights) is the order of 0.004 pound (at the tow line) and by calibration is readily determinable as a function of speed to within 0.0001 pound. Thus the instrumentation will measure towing forces to within 0.0001 pound. This sensitivity and accuracy were obtainable as a result of the precision machine work done by the M.I.T. Instrumentation Laboratory where the pulley assemblies were made.

Additional weights, called acceleration weights, are attached to one of the weight pans at the beginning of a run. After the model has traveled a certain distance along the tank, the acceleration weights enter mercury pools and are floated off the pan. From this point on, the towing weights remaining in the weight pan maintain the speed of the model. The height of the mercury pools can be adjusted to remove the acceleration weights after the model has traveled anywhere from zero to 60 feet along the tank. The purpose of the acceleration weights is to bring the model to the proper speed quickly so that most of the run will be at the desired constant speed. By gradually floating off the acceleration weights, shock and vibration in the towing cord are minimized.

The pulley assembly is mounted on a bronze shelf at the drive end of the tank where the weight pans are located. To this shelf is attached a dynamometer cabinet, which is accommodated in a well 3 feet in diameter and 12 feet long, which houses the mercury cups, weight pans, and acceleration weights throughout their travel. The whole assembly of pulley, shelf, and dynamometer cabinet ride vertically on machined rails and can be raised and lowered electrically. By means of this arrangement, the whole apparatus can be quickly lowered to accommodate any desired water level in the tank and still remain aligned and ready for immediate use after the height is set.



Model of merchant ship hull being towed (right to left) in the M.I.T. Towing Tank. Three 10-foot sections of the tank have glass walls which permit visual and photographic studies to be made. Portions of two glass panels are shown here.

Electronic speed indicator and dynamometer at the drive end of the tank. The drive pulley is atop the open dynamometer cabinet and circular well, opened to view. The electronic speed indicator is on the desk.

Measuring Speed by Electronics. By means of electronic instrumentation, the speed of the model is measured at an idler pulley mounted at the far end of the tank. The diameter of the pulley is such that one revolution per second is equivalent to a model speed of two knots. A black anodized sheet-aluminum disk mounted on the periphery of the idler pulley has 2,000 uniformly spaced radial slits, each of which is 0.008 inch wide and one quarter of an inch long. Thus, during a counting time of one second, each slit represents a speed of 0.001 knot. A light source (beamed through an optical system) and a phototube are mounted with the slotted disk between them, so that the phototube receives a light impulse every time a slit passes the center of the optical system. The output of the phototube is amplified and transmitted to an electronic counter located at the drive end of the tank. The electronic device counts the number of light impulses produced as the slits pass the phototube. The count is automatically cut off at the end of a second by means of a crystal time gate (accurate to 10^{-6} second). The number of pulses counted per second, which represents directly the speed in knots, is flashed on a five bank number board whose capacity is 100,000 counts per second. Thus the speed of the model, accurate to 0.001 knot, is indicated by illuminated numerals which can be recorded. A recycling circuit, displaying the speed every one and a half seconds, provides a visual method of observing whether the model has reached constant speed or is still accelerating during a run where constant speed is desired.

The electronic device is also equipped with a switch which throws out the time gate and allows the count to be started and stopped manually. The counting interval may be made equal to the time the model travels a known distance along the tank, and the count subsequently compared to the distance traveled by the model, thus checking the towing apparatus for slippage. The instrument can be easily checked at any time by a built-in 100,000 cycle testing circuit.

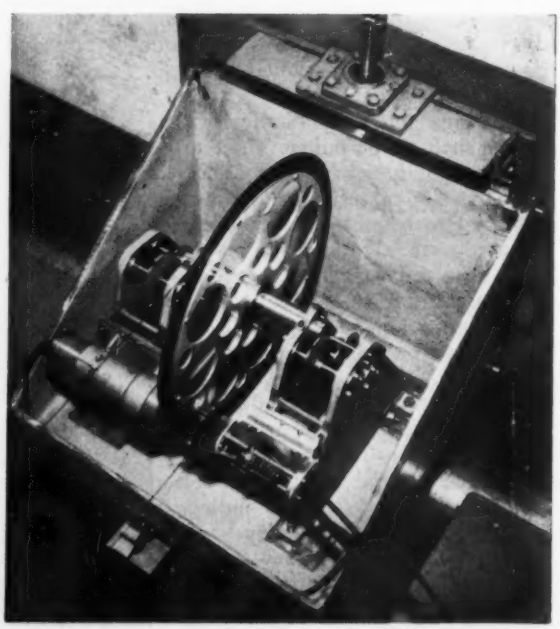
In order to obtain the necessary information from towing tests in waves, it is possible to attach an integrator circuit to the counter unit by means of which a continuous plotted record of speed of the model may be obtained. The integrator unit will be added to the instrumentation in the near future.

The arrangement of the instrumentation is such that, if necessary, one person can conduct a model test from the drive end of the tank, according to the following procedure. The desired unbalance in the weight pans is made by removing a certain weight from one pan and placing it into the other pan. The mercury cups are then set at the proper distance. The model is then released by means of an electrical switch and the speed is observed on the electronic speed indicator. The towing force is recorded as one-tenth the difference of the weights on the pans minus the calibrated friction for the speed observed. As a result, the towing force or model resistance (known to 0.0001 pound) required to tow the model at a certain speed (accurate to 0.001 knot) is readily and effectively determined.

Future Plans. Plans for future instrumentation for the Ship Model Towing Tank call for a wave-generating device, a towing carriage, and an internal six-component dynamometer for stability studies. The tank will be used for student instruction and theses, for research and development work, and for commercial testing.

The Ship Model Towing Tank was set in operation on February 20, 1951, when the first tests were run by students as part of their instruction work in the subject "Dynamics of Ship Design." For the remainder of the term, the tank was in continual use for instruction and thesis projects.

The Department of Naval Architecture and Marine Engineering is very much pleased by the deep interest shown in the new Ship Model Towing Tank by the numerous visitors who have already had the opportunity to inspect this new research facility. An invitation to visit the tank is extended to Alumni and friends of M.I.T.



Idler pulley assembly showing the slotted disc and phototube (lower left-hand corner of cabinet) used for speed determinations.

The Role of the "Mariner"

Construction of a Merchant Fleet of Fast, New Vessels Is Required for National Security and the Safe Conduct of International Trade

By EDWARD L. COCHRANE

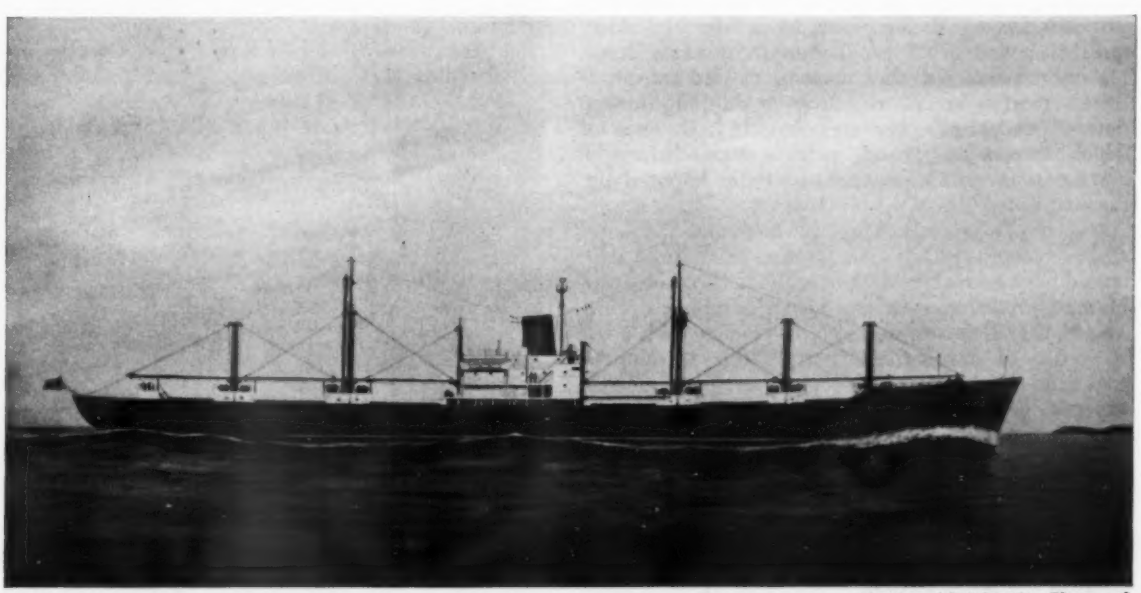
THE role as leader of the freedom-loving nations of the world has been thrust upon the United States and with it an awesome responsibility in the mounting conflict of ideologies. Whether the international future is one of a prolonged war of nerves throughout most of the world, or whether a global holocaust has been sparked by the hostilities in Korea, one plain and unalterable fact emerges crystal clear. The United States cannot ever again afford to hedge its responsibility of leadership because our very survival, and the survival of the countless millions of free peoples and those seeking freedom everywhere, depend upon how well we acquit ourselves.

At first glance it appears somewhat out of place to preface a discussion of maritime matters with observations of this character. A closer scrutiny of the basic reasoning behind advocating an American merchant marine of the most modern and best designed ships in the world today, however, brings out for sober reflection the importance, and an ever-increasing importance, of merchant-type ships to our military security and economic well-being.

Any searching analysis of this situation most certainly results in a fundamental conclusion: numbers alone are not enough where merchant sea power is concerned. It is not sufficient to have a given number of ships – whether that number be in the hundreds or the thousands – unless the vessels meet or surpass the exacting specifications imposed by the era of history which exploded upon mankind with the detonation of the first atomic bomb. This is not to say that the merchant marine, now and forever more, must gear its thinking and development solely along lines that its need, in the American scheme of things, is or will be strictly military or semimilitary.

Perhaps never before in history has a greater measure of responsibility for the future fallen upon the maintenance of an American economy and industrial machine. Today our technological system is balanced on the sharp edge of uncertainty as to whether the world can live in peace or may suffer the devastation of an atomic war. In striving to help maintain this precarious balance, the maritime industry has been cast in a role as complex as the future itself.

The complexities revolve around the single point that almost every activity of the merchant marine must be approached with a dual objective of contributing to this nation's security as well as safe conduct of inter-



Maritime Administration Photograph

Artist's drawing of ship of the "Mariner" type, in peacetime garb. These ships will be 525 feet long with a dead weight of 12,500 tons.

U. S. Maritime Commission Photo

Ships of the Victory type, built during the latter days of World War II, are still carrying much sea-borne cargo over the Atlantic and Pacific.

national trade. In all its planning today the merchant marine must, of necessity, proceed with the assumption that an all-out global war could break out at any moment. To follow any other line of reasoning would be a foolhardy gamble against fate and the calculated cunning of the totalitarian forces which would destroy us. In short in this troubled period of international relations, the maritime industry must look to the future with the knowledge and understanding that it may be called upon at any time to provide a sea-lift military life line, or it may be required to continue in large measure its present assignment of bulwarking the economic and industrial defense of the United States. in particular, and of the free nations of the world who stand with us to block the expansion of communist aggression in general.

As vast and great as are the resources of the United States, the widely dispersed raw material reserves do not make this nation self-sufficient. The never-quenched appetite of the giant that is the American industrial machine must constantly be fed, whether its output is for war or for peace. Mountains of fodder for this leviathan of production must come from sources overseas and thus must be carried by ships. But as great as are the demands on shipping during days of peace, or the uncertain days of half peace in which we now find ourselves, these demands largely are inconsequential compared to those imposed by the vital necessities of modern war.

Perhaps it logically could be said that were we still in the pre-Atomic Era, the United States today would have no real maritime problem. The thousands of mass-produced merchant-type ships built during World War II have provided this country with a reserve fleet of vessels that still are usable. In the not-too-distant past, before the atom was transferred from the scientist's vocabulary to its present position in military weapons, perhaps that reserve fleet could fill our need for another five or 10 years.

But not today is the reserve fleet fully capable of meeting the nation's emergency shipping requirements. Even in these days of half peace, all of the speedier, more efficient Victory-type cargo vessels built in the latter days of World War II, have been removed from the laid-up category. The World War II ships, with speeds of 14 and 17 knots, have been placed in service in the Korean lift to augment the merchant fleet carrying cargoes to bulwark the defenses of western Europe and free Asia. In addition to stripping our reserve anchorages of the entire backlog of Victory ships, we now are withdrawing each month sizable numbers of the sturdy, but markedly slow and outmoded, mass-produced Liberty ships which were so familiar to, and vital on, the sea lanes of the 1941-1945 global conflagration.

To meet the obvious and pressing need for additional shipping, the Maritime Administration has launched upon a shipbuilding program aimed to provide the type of sea transport this nation will require in any future world-wide outbreak of hostilities. A newly designed vessel of the "Mariner" class is to be built in sufficient numbers to assure at least the beginning of an adequate merchant-type fleet. Ships of the Mariner class will be designed specifically to meet definite requirements which a group of outstanding experts deem desirable, if not necessary. The fleet of Mariner vessels should provide an adequate role in the nation's peacetime economy and form the backbone of a trooper-cargo armada capable of carrying men and materials wherever the need might arise.

With a dead weight of 12,500 tons, the Mariner has a lift capacity superior to anything of its type we now have afloat, and its speed of 20 knots is double that of the Liberty ships. At present, 25 of these vessels are under construction in five different shipyards. The first of the Mariner class will take to the seas early in 1952. Another postwar ship of advanced design already has been launched by the Maritime Administration. It is a vessel of 10,500 dead-weight tons having a speed of

U. S. Steel Corporation

For standardized vessels, shipbuilding time can be reduced by one third by prefabrication methods in which entire sections, such as the deckhouse and bridge, are lifted into place as was done for this destroyer.

18.5 knots. This vessel is approximately the same size as that of the Liberty and Victory ships but has greater speed and incorporates other developments. This vessel, the S.S. *Schuyler Otis Bland,* is due for delivery early this summer. Experimental use of this vessel will determine its role in peacetime and wartime programs.

Objections have been voiced to the construction of new cargo ships while Victory ships are in wide-spread use, and our reserve fleet still contains the war-built Liberty ships. But these objections result largely from the belief held in some quarters that merely a large number of ships is sufficient to fulfill our maritime needs. Any well-rounded analysis of the situation will shatter this contention.

Consider the case of the Libertys and the Victorys, too, for that matter. It should be remembered that the newest of the Liberty ships is nearly eight years old and that it has been almost six years since a Victory was built. When first laid down for Britain in the spring of 1941, the *Empire Liberty* was a ship built to the particular emergency needs of one seafaring nation. At that time, hardly anyone would have predicted that the *Empire Liberty* would become the prototype of the largest single type of ship ever constructed.

Built in the North Sands yard of the J. L. Thompson Company, Ltd., at Sunderland, England, the *Empire Liberty* was a 9,500-ton tramp. At the time, she seemed just another ship, but destiny had marked a place in history for her regardless of her then old-fashioned reciprocating steam power plant. The *Empire Liberty* was delivered in November, 1941, at a time when the German submarine menace was whittling away at Britain's sea lift in a manner that posed a serious threat to that country's life line. Naval architects and other experts, called in by the Prime Minister to do whatever could be done to provide more ships in a hurry, were sent to the United States to seek out American shipyards which could build at least 60 merchant-type vessels a year for Britain.

In a matter of weeks, American builders had commenced work on the first of the Libertys. At about the same time, the United States found itself at war and in dire need of millions of tons of shipping. Suddenly the United States found itself producing Libertys by the hundreds. Through a combination of American prefabrication techniques and the basic simplicity of the original design, the Libertys were admirably suited for mass production. But the ship itself, which became the most familiar silhouette in the ocean convoys of World War II, achieved its niche in history largely through the pressure of the moment, instead of long-range planning.

The Victorys, which came along later in the conflict, were the result of planning and war-born developments. Like the Libertys, these vessels were the brain children of many persons. But notwithstanding their monumental achievements during World War II, and wide-spread use today, the Liberty-Victory ships were creations which resulted largely from a situation already at hand; namely, the war against the Axis powers.

Since the birth of the Libertys and Victorys much has happened which rules them out of consideration for any future assignment as first-rank vessels in wartime. The inexorable progress of technological advancement and the press of economic developments have placed a mark against them as the type of ships called for in an American peacetime merchant fleet adequate for our future needs.

The Maritime Administration and defense officials are more concerned, at the moment, with new merchant-type ships because of the beclouded international outlook. Out of the Korean situation has grown the firm conviction that we must be ready, with fast dry-cargo vessels, to transport the military strength of this country to whatever danger area may develop.

As ominous and dark as the war clouds of the present may be, however, a large portion of the efforts of the American merchant marine must be channeled into enterprises not directly concerned with the military. The United States is bent on having peace and there still exists hope that another global war may be averted. To a major degree, whatever peace the world may enjoy must result from the willingness of the democratic nations of the world to make and keep themselves sufficiently strong to dissuade any potential aggressor from launching a full-scale attack on Western civilization and ideologies.

With this as an accepted premise, it must be held firmly in mind that it is not enough for the United States merely to ward off possible military attack. The American economy must also be marshaled in such a manner as to guarantee that our way of doing business does not falter or fail. Should the American economic system collapse, Communism would certainly be advanced as the only alternative for millions of people everywhere, and the cause of freedom would be perhaps forever lost.

To bulwark the American industrial machine with raw materials transported from sources overseas, and to provide our friends abroad with United States products — be it food or manufactured goods — are tasks only merchant ships can perform adequately. In time of peace, as history has so often shown, America must

(*Continued on page 422*)

Maritime Administration Photograph

Produced in large quantities early in World War II, Liberty ships of the type shown here will ultimately be replaced by the faster "Mariner" type of ships.

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

Secretary of M.I.T.

APPOINTMENT of Walter H. Gale, '29, Associate Professor of Aeronautical Engineering, as Secretary of the Institute was announced on May I by James R. Killian, Jr., '26, President of M.I.T. As secretary of the Institute, a new administrative post, Professor Gale will have executive responsibilities for the Institute's broad program of external relations and development of resources.

In addition, he will serve to facilitate the work of the officers, members, and committees of the M.I.T. Corporation, working particularly with the departmental Visiting Committees of the Corporation and with the projected new Standing Committee on Development. Professor Gale will also be responsible for planning and co-ordinating more extensive alumni organization for the recruitment and counseling of prospective students, with the collaboration of the director of admissions.

In line with the general duties of his office, Professor Gale will have administrative direction of the following offices and programs: the Development Office which is to be established on a permanent basis; the organization and extension of the Institute's system of alumni counselors for prospective students; the Industrial Liaison Office, established in 1949 to make available to industry on a co-operative basis the vast research facilities of the Institute; the News Service; the newly created Publications Office whose purpose is outlined on this page; and the Summer Session, which in recent years has been expanded to offer courses to industrial research workers and science teachers, as well as to the M.I.T. student body.

M.I.T. Photo

Walter H. Gale, '29
Secretary of the Institute

Professor Gale, son of the late Permelia N. Pettigrew of Short Hills, N.J., and Oliver M. Gale, advertising executive and author, was born in Ventura, Calif., on July 18, 1906. After attending the Choate School in Wallingford, Conn., and graduating from Lane Technical High School in Chicago, Professor Gale entered M.I.T. He received the degrees of bachelor of science in 1929 and master of science in 1930. Until 1935 Professor Gale was research assistant in M.I.T.'s Aeronautical Engineering Department; served the following year as project engineer at the Bendix Aviation Corporation; and from 1936 to 1942 as sales representative for the M. B. Skinner Company. As a lieutenant commander in the United States Naval Reserve, Professor Gale served in the Bureau of Aeronautics from 1942 to 1945, where he was project supervisor of the Experiments and Developments Branch, and head of the Structural Modification Section, Structures Branch.

Since 1946 he has been associate professor of aeronautical engineering, budget officer and deputy executive officer of the Department of Aeronautical Engineering, and director of the Summer Session at the Institute.

Publications Office Formed

SINCE 1945 director of publications of the Carnegie Institution of Washington, Frederick G. Fassett, Jr. has been appointed director of the Publications Office at M.I.T. "In addition to heading the Publications Office, Mr. Fassett is to be director of the Technology Press, and will have charge of the Institute's Summer Session," President Killian stated in making the announcement.

The new Publications Office has been established to consolidate the planning and preparation of all the Institute's official publications, and to insure that they best serve the educational objectives of the Institute and reflect its high standards. The office will have responsibility for the Institute's catalogue, its official announcements, and other documents and printing.

As director of the Technology Press, Mr. Fassett will have responsibility for the growing number of scholarly publications issued under the imprint of the Institute. As director of the Summer Session, he succeeds Walter H. Gale, '29, Associate Professor of

Aeronautical Engineering, who has just been appointed secretary of the Institute. Mr. Fassett will continue the development of the Institute's summer program, extending its scope and its service to industry and education.

Having joined the staff of the Department of English and History as an instructor in 1930, Mr. Fassett is already thoroughly familiar with M.I.T. He became an assistant professor in 1934, and associate professor in 1938. From 1934 to 1938 he was chairman of first-year instruction in his Department and served as a member of the committees on revision of the curriculum, first-year instruction, and admissions.

From November, 1938, until he left the Institute to take his post with the Carnegie Institution of Washington in 1945, Mr. Fassett was editor of The Review. For his distinguished service to M.I.T. Alumni during the seven years when he was The Review's editor, Mr. Fassett was made an honorary member of the Alumni Association in 1945.

Bachrach

Frederick G. Fassett, Jr.
Director, M.I.T. Publications Office

Born in Portland, Maine, in 1901, he is the son of the late Frederick G. Fassett, editorial writer for the Boston *Transcript*. He was educated in the public schools of Portland and Waterville, and Coburn Classical Institute of Waterville. He then entered Colby College, from which he holds the degrees of bachelor and master of arts. He is also a graduate of the University of Maine, which awarded him the degree of master of arts in 1930. In 1931-1932 he carried on graduate studies at Harvard University. His major fields of research have been American literary history, logic and analysis, and rhetoric. He is the author of *A History of Newspapers in the District of Maine from 1785 to 1820; Practical Writing*, and *Studies in Reading*, both in collaboration with Paul C. Eaton, '27, formerly Assistant Professor of English in the M.I.T. Department of English and History. He has written numerous newspaper and magazine articles, as well as considerable verse.

We Elect

Votes cast by Technology Alumni this spring in the annual democratic process of selecting new officers for the Alumni Association resulted in the election of Alfred T. Glassett, '20, as president of the Association for the year beginning July 1, 1951. Hugh S. Ferguson, '23, was brought into office as vice-president for a two-year term. Royal Barry Wills, '18, and George W. McCreery, '19, were elected to two-year terms on the Executive Committee.

Nominated by the Alumni, to serve for five years as term members of the M.I.T. Corporation are: John A. Lunn, '17; Howard H. McClintic, Jr., '19; and David A. Shepard, '26.

For election to membership on the National Nominating Committee, 3,678 valid ballots were cast, and the following candidates were declared elected: George E. Colby, '32, for District 3; George P. Edmonds, '26, for District 6; and Harold E. Koch, '22, for District 7. All will take office on July 1 for a term of three years.

Classes whose numerals end in two or seven chose members to represent their class on the Alumni Council. Elected to serve for five-year terms are: Charles E. Fuller, '92; John P. Ilsley, '97; Frederick H. Hunter, '02; George A. Crane, '07; John M. Pettingell, '12; Frederick Bernard, '17; A. Robert Tonon, '22; Dwight C. Arnold, '27; Thomas E. Sears, Jr., '32; Philip H. Peters, '37; Louis Rosenblum, '42; and James L. Phillips, '47.

It is gratifying to note that the number of Alumni taking part in balloting has steadily increased since the end of World War II.

Student Government Aided

A grant of $10,000 from the Vannevar Bush Trust to aid students in the development of qualities of leadership and resourcefulness has been announced at the Institute. While the grant was made without restriction, the trustees suggested that $500 be awarded annually from the income and principal of the fund to the undergraduate head of student government to defray expenses incident to his office.

In making the suggestion, Oscar S. Cox, '27, a trustee of the Vannevar Bush Trust, said:

> A special grant to the elected head of the student government should assist him to discharge his duties more effectively and at the same time should serve as an incentive for the entire student body to interest itself in government and human relationships and to develop the qualities necessary for that purpose. The trustees were led to this suggestion by the conviction that one of the best ways to further scientific progress is to develop qualities of leadership and resourcefulness, not only as applied to scientific problems, but also as applied to the complex fields of government and human relationships.

The first award from the grant will be made to Robert M. Briber of Denver, Col., newly elected President of the Class of 1952, who will apply the funds for the organization of a leadership conference for members of the Institute Committee.

The Vannevar Bush Trust was established by Vannevar Bush, '16, President of the Carnegie Institution of Washington, from the entire proceeds of his book, *Modern Arms and Free Men*. Dr. Bush has served the Institute in many capacities until called to his present position.

Class Reunions

The Review is happy to reprint below information on class reunions which appeared in the April issue, and also lists additional data received since the publication of the April Review.

1891 June 9. Dinner at 1:00 P.M. at The Country Club, Brookline, Mass.; Harry H. Young, reunion chairman, J. L. Hammett Company, 290 Main Street, Cambridge 42.

1896 June 8 and 9. New Ocean House, Swampscott, Mass. Dr. John A. Rockwell, reunion chairman, 24 Garden Street, Cambridge 38.

1900 June 12-14. The Pines, Cotuit, Mass. Elbert G. Allen, secretary, 11 Richfield Road, West Newton 65.

1901 50th reunion. June 8, participation in commencement activities; June 9 and 10, Oyster Harbors Club, Osterville, Mass.; June 11, special class table at Alumni Day luncheon in Du Pont Court. Philip W. Moore, reunion chairman, 1031 Fishers Lane, Hubbard Woods, Ill.

1905 June 15-17. East Bay Lodge, Osterville, Mass.

1906 June 12-14. Snow Inn, Harwichport, Mass. James W. Kidder, reunion chairman, 215 Crosby Street, Arlington 74, Mass.

1911 June 8-10, returning to Cambridge for Alumni Day, June 11. Snow Inn, Harwichport, Mass. Alexander W. Yereance, reunion chairman, 80 Federal Street, Room 704, Boston 10.

1916 June 8-10. Coonamessett Inn, North Falmouth (Cape Cod), Mass. Class get-together at Copley Plaza on June 11 in afternoon. Ralph A. Fletcher, reunion chairman, P.O. Box 71, West Chelmsford, Mass.

1921 June 8-10. Sheldon House, Pine Orchard, Conn. Class get-together at Copley Plaza on June 11 in the afternoon. Irving D. Jakobson, reunion chairman, Jakobson Shipyard, Inc., West End Avenue, Oyster Bay, Long Island, N.Y.

1926 25th reunion. June 9 and 10. Hotel Griswold, New London, Conn., returning to Cambridge for Alumni Day, June 11. Alfred H. Dolben, reunion chairman, 17 Bond Street, Reading, Mass.

1931 June 9 and 10. Mattapoisett, Manor, Mattapoisett, Mass. August L. Hesselschwerdt, Jr., reunion chairman, 28 Hillcrest Road, East Milton.

1936 June 9 and 10. Weekapaug Inn, Westerly, R.I. Fletcher P. Thornton, Jr., reunion chairman, W. E. Green Corporation, Woolworth Building, New York 7, N.Y.

1941 June 9 and 10. Hotel Curtis, Lenox, Mass. D. Reid Weedon, Jr., reunion chairman, 4 Overlook Way, Winchester, Mass.

1946-2 June 9 and 10. Everett Moore Baker House, M.I.T. All members of Class of 1946 invited. Theodore P. Heuchling, reunion chairman, Servomechanisms Laboratory, Building 32, M.I.T., Cambridge 39.

1946-6 Donald A. Hurter, reunion chairman, 108 Vernon Street, Norwood, Mass. See listing above for Class of 1946-2 for date and place.

Alumni who may be planning to attend reunions this year are urged to consult their class secretary or reunion chairman for later details or more complete information not included in this tabulation.

Council Meets New Dean

TRENDS in architectural education and progress in jet propulsion took the spotlight at the 282d meeting of the Alumni Council held in the Campus Room of the M.I.T. Graduate House on April 30. In the absence of John A. Lunn, '17, President of the Alumni Association, who was unavoidably out of town, Horatio L. Bond, '23, presided.

During the business portion of the meeting, Donald P. Severance, '38, Alumni Secretary, reported for the Executive Committee that the treasurer's budget for the fiscal year 1951-1952 had been examined and approved, and that the treasurer had been authorized to subsidize Alumni Day expenses, up to $800, with funds from the Reunion Reserve Fund. Also reported were changes in the class affiliation for four Alumni, and the fact that between March 26 and April 24, nine Faculty and Council members had visited 13 clubs. It was also voted to recognize the newly established M.I.T. Club of Puerto Rico which had its organization meeting on March 31 when H. E. Lobdell, '17, Executive Vice-president of the Alumni Association, visited San Juan.

As general chairman of Alumni Day, 1951, Allen Latham, Jr., '30, reported on plans for the reunion to be held in Cambridge on Monday, June 11. By the time this issue of The Review is distributed, programs will already have been put in the mail.

Mr. Bond next introduced Karl T. Compton, chairman of the M.I.T. Corporation, who discussed the origin of the Ford Foundation and its current activities. He spoke of the Foundation's approach to determining the areas of work it would support and explained briefly the manner in which the Foundation expects to operate in about five areas.

Dr. Compton then presented Pietro Belluschi, new Dean of the M.I.T. School of Architecture and Planning. Dean Belluschi spoke on his concept of the changes which have taken place in the role of the architect during the past 25 years and the consequent new role of architectural education. He stressed that architecture in this age is more for the average person, not just for a selected few.

Mr. Bond then introduced Professor Edward S. Taylor, '24, of the Department of Aeronautical Engineering, who spoke on jet propulsion. He discussed briefly the history of the development of jet civil transportation and military use of jet propulsion. He also predicted the probable effects of increased use of jet propulsion, and forecast that the indirect benefits in this field would far exceed the more obvious ones.

Along the Main Stream

PROMOTIONS on the Faculty of the Institute, recently announced, include six members who are advanced to full professorships and 18 to associate professorships. Promotions and new appointments to assistant professorships number 27. These advancements will become effective on July 1.

Members promoted to the rank of full professor are: Herman P. Meissner, '29, Department of Chemical Engineering; Isadore Amdur, Department of Chemistry; Charles H. Norris, '31, Department of Civil and Sanitary Engineering; Charles P. Kindleberger, Department of Economics and Social Science; William H. Radford, '32, Department of Electrical Engineering; and Francis Bitter, Department of Physics. Photographs of this distinguished group are shown below in alphabetical sequence in counterclockwise order.

Assistant professors promoted to the rank of associate professor are: H. Guyford Stever, Department of Aeronautical Engineering; Major Lyman R. Blake, Department of Air Science and Tactics; Lockhart B. Rogers, Department of Chemistry; Lloyd Rodwin, Department of City and Regional Planning; E. Cary Brown, Department of Economics and Social Science; Donald P. Campbell, '43, and Robert M. Fano, '41, both of the Department of Electrical Engineering; Klaus Liepmann, Department of English and History; Patrick M. Hurley, '40, Department of Geology; George W. Whitehead, Department of Mathematics; Stephen H. Crandall, 2-46, and Prescott A. Smith, '35, both of the Department of Mechanical Engineering; Amos J. Shaler, '40, Department of Metallurgy; Thomas F. Malone, 2-46, Department of Meteorology; Major Augustine M. Fragala, Lieutenant Colonel Samuel L. Hall, and Lieutenant Colonel Finis G. Johnson, all of the Department of Military Science and Tactics; and William W. Buechner, '35, Department of Physics.

Those to become assistant professors are: Elmer E. Larrabee, '48, Department of Aeronautical Engineering; Robert B. Newman, '49, School of Architecture; Herman C. Fischer, '50, and Werner H. Gumpertz, '48, both of the Department of Building Engineering and Construction; John H. Kempster, '47, and Leo B. Moore, '37, both of the Department of Business and Engineering Administration; Raymond F. Baddour, '49, James C. Bresee, and Jacob M. Geist, all of the Department of Chemical Engineering; David Shoemaker, Department of Chemistry; Harl P. Aldrich, Jr., '47, John S. Archer, '48, and Henry M. Paynter, 10-44, all of the Department of Civil and Sanitary Engineering; John R. Coleman, Department of Economics and Social Science; Jordan J. Baruch, '47, Elery F. Buckley, '49, James M. Ham, '47, F. Ralph Kotter, Osman K. Mawardi, Ronald E. Scott, '50, and Albert B. Van Rennes, 10-44, all of the Department of Electrical Engineering; W. H. Sterg O'Dell and Gregory Tucker, both of the Department of English and History; Fredman J. Walcott, Jr., 2-44, Department of Mechanical Engineering; Morris Halle, Department of Modern Languages; and William L. Kraushaar and Karl U. Ingard, '50, both of the Department of Physics.

A newly appointed visiting professor in the Department of Naval Architecture and Marine Engineering is Laurens Troost of Delft Technical College.

Twenty-two members of the staff have been advanced to the rank of instructor in seven of the Institute's Departments in the Schools of Engineering, Science, Humanities and Social Studies.

◀ I. Amdur

W. H. Radford, '32 ▶

F. Bitter

C. P. Kindleberger

H. P. Meissner, '29

C. H. Norris, '31

M.I.T. Photos

At the victory dinner honoring Alfred P. Sloan, Jr., '95, and members of the Committee on Financing Development at the Waldorf-Astoria Hotel on May 3, M.I.T. President Killian presented to Mr. Sloan a volume of 2,000 signatures in testimony of his leadership in American industry and education. Below (left to right) *are shown the principal speakers: President Killian, Mr. Sloan, Paul G. Hoffman, and Karl T. Compton.*

Sam Vandivoert

Development Program Victory Dinner

More than 1,000 leading industrialists, educators, and distinguished representatives of the professions gathered at the Waldorf-Astoria Hotel in New York on Thursday evening, May 3, at a victory dinner in honor of Alfred P. Sloan, Jr., '95, chairman of the Board of General Motors Corporation. The dinner marked the successful completion of the $20,000,000 Development Program launched by the Institute's Committee on Financing Development in November, 1948, with Mr. Sloan as honorary chairman. By January, 1951, a total of $20,100,000 had been contributed and pledged to this program, not including a special gift of $5,250,000 from the Alfred P. Sloan Foundation for the establishment of a new School of Industrial Management now being organized.

Mr. Sloan addressed the group on the importance of fundamental knowledge and outlined his views for providing "an opportunity for the young men of today better to prepare themselves to meet the exacting demands of industrial management as they become industrial executives of tomorrow." It is planned to publish his address in a forthcoming issue of The Review. Other speakers included: Paul G. Hoffman, President and Director of the Ford Foundation; Karl T. Compton, chairman of the M.I.T. Corporation; and President Killian. Edward Pennell Brooks, '17, who will take over the duties of dean of the School of Industrial Management in September was introduced, and also spoke briefly. Marshall B. Dalton, '15, who served as general chairman of the Committee on Financing Development, presided.

Speaking in tribute of Mr. Sloan's contributions to American industry and education, President Killian found opportunity to comment on the current need for adequately supporting institutions of higher learning. With special reference to the recently concluded Development Fund, President Killian found encouragement in the "convincing demonstration of the willingness of public-spirited individuals and corporations to provide adequate support to our privately endowed and privately controlled educational institutions." Dr. Killian observed that were this nation forced to give up academic freedom and if our institutions should lose their independence, one of the foundation stones of our free enterprise system would be lost. "The M.I.T. Development Program," stated President Killian, "has served to stimulate and to establish a new and fruitful relationship between education and industry. It has demonstrated that industry feels that it has a stake in educational free enterprise, and that the future strength of our industrial system is in part dependent upon the men and the ideas which flow out of the educational institutions."

As a token of appreciation of Mr. Sloan's leadership, President Killian presented to Mr. Sloan a testimonial

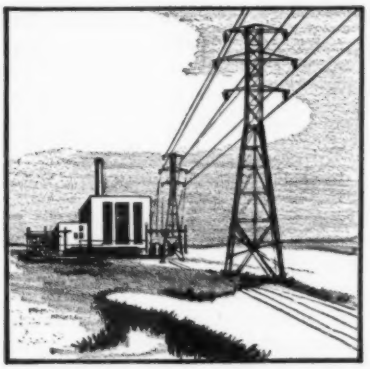
(*Continued on page 416*)

BUSINESS IN MOTION

To our Colleagues in American Business . . .

Like other suppliers, Revere offers its metals in a wide variety of alloys. This is for the reason that no one metal or alloy is suitable for every purpose, for every requirement. In order to help solve the sometimes complex problems that arise concerning metal specification, fabrication, and use, Revere offers the services of its Technical Advisory Staff. Here is an example of its work.

When an electric utility was re-tubing a condenser, Revere Research had an opportunity to obtain samples of the tubes that were removed. A laboratory examination showed them to be made of an excellent alloy; let us call it "Alloy X," since the tubes were made by a competitor. This alloy is usually specified for conditions of erosion-corrosion, but our examination indicated that the tubes also were subject to severe attack by air entrainment and high-velocity, turbulent water. The Revere Technical Advisor, who inspected the condenser in person, suggested that longer tube life might be obtained if cupro-nickel in the 10% nickel alloy were used. As a test, 50 such tubes were installed alongside the new "Alloy X" tubes.



At the end of only three months, the utility was disturbed to find that some of the "Alloy X" tubes were beginning to fail. Samples were sent to Revere Research, which once again reported that these competitive tubes were good ones, mechanically and as to alloy. The Revere Technical Advisor immediately returned to the utility, where he spent two days and nights on the job, much of the time inside the condenser itself. He found the cupro-nickel tubes in fine condition. Recommendations included putting a perforated iron sheet in the water box to reduce turbulence and air entrainment, and the use of 10% cupro-nickel tubes throughout. These suggestions were followed.

Two years later the cupro-nickel tubes were inspected, and found to be in excellent condition. As a result, a new generating station of the company was equipped with them.

Please note our statement that the tubes made by a competitor were all right as tubes. If Revere Tubes in the same alloy had been installed there, the same trouble would have been experienced. It was natural enough for the utility to blame the tubes, but Revere knows that if condenser tubes do not give long and economical service the fault most probably lies in the selection of an alloy unsuitable for operating conditions. In many cases, as in this one, Revere has been able to suggest changes in alloy or in operation, or both, bringing about important economies for users of condensers.

What Revere does in this way is not unique by any means. Suppliers in every industry do as much for their prospects and customers, every day in the week. They do it gladly, because a happy, satisfied customer is a precious asset. So we suggest that no matter what your business is, no matter what you buy, nor from whom, you take your suppliers into the closest possible confidence, permitting them to learn all they can about the conditions their materials have to meet. This will cost you nothing, and may save you much.

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(*Continued from page 414*)

volume signed by all members of the M.I.T. Corporation and Faculty, members of the Alumni Council, and guests at the dinner, among whom were many members of the National Development Committee. The volume contained approximately 2,000 signatures.

In his address, Mr. Hoffman called for unity of purpose and action, not alone within the borders of the United States but with all people intent on "waging peace." He warned that the United States might face disaster if it failed to maintain unity with western Europe against the threat of Communist aggression. He expressed the beliefs that: "an enduring peace built on freedom and justice can be won if the free people of the world will dedicate themselves unreservedly to the task; and peace can be won only if the free people everywhere lock arms so tightly in the common cause that no force can tear them apart." Mr. Hoffman stated: "A new kind of leadership is called for." He believes that "unless we consecrate ourselves as wholly to winning the peace as we have from time to time consecrated ourselves to military victory, the prospects are dim indeed. Peace has to be worked at, not dreamed about and left to someone else."

Industrial Liaison Office

More and more large industries are beginning to realize that their leadership tomorrow must stem from an awareness and understanding of the new scientific knowledge and techniques of today. For any one industry the fact applies not to one research field alone, but, increasingly, to all sciences and fields of engineering. Yet the scale and pace of modern research are such as often to cause industry to lag behind, by many months or even years, in its knowledge of current research progress.

To assist in this industrial problem, during the past three years the Institute has evolved its Industrial Liaison Program, constituting a mutually helpful arrangement with a large and representative group of the nation's leading industrial corporations. In return for essentially unrestricted financial support, the Institute undertakes to establish with these companies the closest possible relationship which can be of authentic benefit to both the Institute and industry.

Under this program the Institute also benefits, and in several ways. New and convenient methods are opened up for Faculty members to enlarge their service to industry. Contact with industry provides live and worth-while topics for thesis work so that students derive stimulation through contact with "live" problems. The program also provides increased opportunities for effective placement of graduates through better mutual knowledge of situations and personnel involved. Finally, such co-operation provides a climate more favorable to increased industrial support of specific projects.

Every effort is made to individualize the Institute's relationship with each company participating in the program. Among the regular services which the Institute renders may be included the holding of industrial conferences of informal nature in research fields of common interest and usually at a high professional level. Industrial representatives are encouraged to visit the Institute for brief informal contacts with individual Faculty members. The primary purpose of such visits is to acquaint industrial personnel with the "state of the art" in the many fields represented with special competence by the M.I.T. Faculty. Representatives from industry are welcomed by the Institute to work on particular projects for specified periods of time for the purpose of learning new research techniques in fields where Institute facilities and space are available for the purpose. Finally, every effort is made to provide companies with reports of activities at M.I.T. in which the companies may have an interest.

The operation of this program is the responsibility of the Industrial Liaison Office, under the direction of Robert V. Bartz, 2-44. Associated with Mr. Bartz in the Industrial Liaison Office are: Rowland S. Bevans, 2-46, William R. Weems, '35, David I. Sinizer, '51, and Walter L. Allison, '51. Warren K. Lewis, '05, Professor Emeritus of Chemical Engineering, has been associated with the office as consultant.

L.I.S. Graduation

Ralph Lowell, trustee of the Lowell Institute School and member of the M.I.T. Corporation, awarded certificates to approximately 80 students at the 47th graduation exercises of the Lowell Institute School held in Huntington Hall on Thursday evening, May 24.

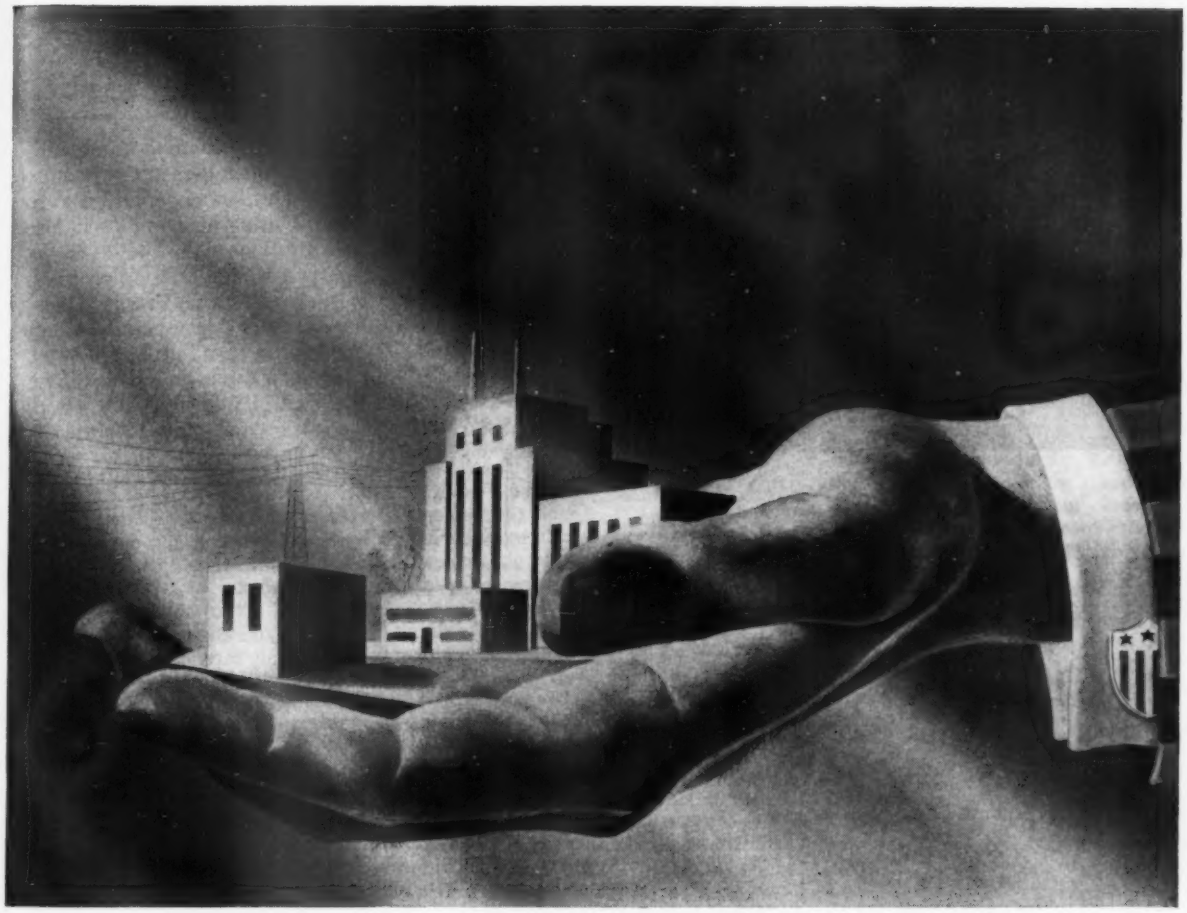
Greetings from President Killian and members of the M.I.T. Corporation were conveyed by Thomas K. Sherwood, '24, Dean of Engineering, who spoke for the Institute in his first appearance at Lowell School graduation exercises. William C. White, Dean and Director of Day Colleges at Northeastern University, and widely known in the field of engineering education, gave the principal address to the graduates. Arthur L. Townsend, '13, Director of the Lowell Institute School, presided at the exercises.

Sir Roderic Hill Visits M.I.T.

In the conduct of an educational program, the promotion of international relations looms large. The program of student study in Sweden last summer, already recorded in The Review (February, 1951), and the Foreign Student Summer Project which has operated for several years, are prime examples of opportunities afforded students in one country to learn how students in other countries live. So, too, are the crew races on the Charles, during which Cambridge University took the lead over Harvard, Boston University, and M.I.T. in April.

But students are not the only ones to have such advantages. Sir Roderic Hill, Rector of the Imperial College of Science and Technology in London, has come to M.I.T. to spend a portion of his vacation while Professor Joseph H. Keenan, '22, of the Department of Mechanical Engineering, is at present studying at the

(*Continued on page 418*)



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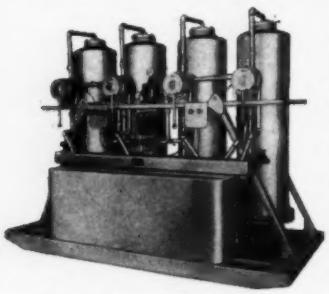

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THE INSTITUTE GAZETTE

(*Continued from page 416*)

Imperial College. Sir Roderic has come to Cambridge to meet President Killian and members of the Faculty with whom he has had correspondence, and also to make new acquaintances. During his trip he will also visit other educational institutions in the United States.

A most enjoyable feature of Sir Roderic's visit was the dinner he gave for members of the Faculty Council in behalf of the Governors of the Imperial College of Science and Technology, at the Club of Odd Volumes on April 11. Speaking of the common objectives of the London and Cambridge institutions, Sir Roderic commented on the role of technologists in the following words:

The Twentieth Century is the heyday of the scientist and the engineer. More and more of our young people will receive their professional education in some scientific or technological field. Let us not regret this. Let us not apologise for it. Rather let us rejoice. . . .

Be that as it may, if a liberal education is given with a sense of the dignity of science and engineering, it can be no less useful to man in achieving serenity and happiness in guiding his own destiny than its practical consequences have for his material well-being. It requires that science, a knowledge of nature and oneself, should be an essential ingredient, an equal partner in any education for a civilised man.

Whether we regard this training as turning men into scientists, engineers — and in your case also architects — or whether we look upon it as a process of turning scientists and engineers into men, we both have a great mission to fulfill. An understanding, such as I trust will ripen as the years go by between our two institutions, will help to focus and conserve what is precious in the great field of education in which we work.

From Industry to Classroom

FOURTEEN young industrial executives, winners in a nationwide competition, have been awarded Alfred P. Sloan Fellowships for Executive Development. These provide an intensive one-year program at M.I.T. for study of management policies and economic and social problems of industrial administration. These men, who have been nominated by their employers as showing unusual promise for industrial leadership, will receive fellowships up to $3,700. They will be on leave from their companies and upon com-

(*Concluded on page 420*)

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INVENTIVE Americans are often hamstrung today. Not because of any lack of ideas, but because of a need for large and expensive facilities to find out if and how their ideas work.

This was no obstacle in our earlier days. With nothing but his own hands and a few dollars, Henry Ford proved that he could build an automobile that ran. Eli Whitney built his cotton gin in a barnyard with homemade tools—and it worked.

In contrast, the first pair of nylon stockings took ten years of research time and $70,000,000.

Today, science and invention have become so complex that a man with an idea for a better product often needs the assistance of an army of specialists and millions worth of equipment to prove his idea has commercial value.

Within the petroleum field, The Sinclair Plan now offers to provide that assistance.

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Under this Plan, Sinclair is opening up its great research laboratories at Harvey, Illinois, to independent inventors who have sufficiently good ideas for better petroleum products.

Sinclair Research Laboratories have nine modern buildings equipped to handle every phase of petroleum research. These laboratories were built with an eye to the future, and their potential capacity is larger than is required for current work. This capacity will be made available for developing the best ideas of outside inventors.

If you have an idea for a better petroleum product or for a new application of a petroleum product, you are invited to submit it to the Sinclair Research Laboratories, with the provision that each idea must first be protected, in your own interest, by a patent application, or a patent.

If the directors of the laboratories select your idea for development, they will make, in most cases, a very simple deal with you: In return for the laboratories' investment of time, facilities, money and personnel, Sinclair will receive the privilege of using the idea free from royalties. This in no way hinders the inventor from selling his idea to other companies or from making any kind of arrangements he wishes without further reference to Sinclair.

How to Participate

Instructions on how and where to submit ideas under The Sinclair Plan are contained in an Inventor's Booklet that is available on request. Write to: Executive Vice-President, Sinclair Research Laboratories, Inc., 630 Fifth Avenue, New York 20, N. Y. for your copy of this booklet. *Important:* Please do not send in any ideas until you have sent for and received the instructions.

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THE INSTITUTE GAZETTE

(Concluded from page 418)

pletion of the program will return to the same companies. In announcing the winners of the fellowships, Gerald B. Tallman, Associate Professor of Marketing, who is director of the Sloan Program, said:

This program provides an unusual opportunity for men of marked ability to study and evaluate business and economic problems with a mature viewpoint engendered by 10 years or more of practical business experience. The advantages of building some part of a man's formal education upon a background of practical experience is widely recognized, but the demand for continuity in business service and the financial burden of growing families thwarts this dream for most men. The farsighted co-operation of the Alfred P. Sloan Foundation and of employing companies, however, makes this program possible for a limited group of men selected on the basis of having shown unusual promise for leadership in business and their community.

During the period of study, the men will discuss problems of business management, of industrial and human relations in industry, and of the responsibilities of industry in regard to national and international problems. Through the study of business problems the men will seek to gain a better appreciation of the varying objectives and points of view of different elements in society, in industrial relations, financial management, marketing, production, and accounting.

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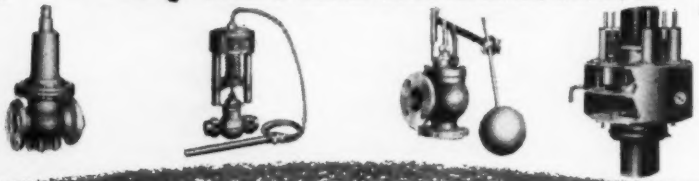

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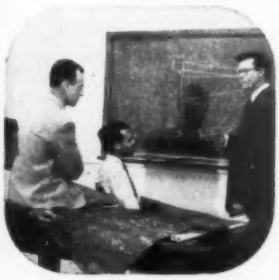

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ROLE OF THE "MARINER"

(Continued from page 409)

import mountains of raw materials and must have export markets for finished goods if the U.S. economy is to expand in a healthy manner. In time of war, the same foreign lands that provide resources and markets become our life-or-death allies; they, as well as we, depend on the sea lanes (and thus ships) for the vital transportation connecting link that spells out the difference between victory or defeat.

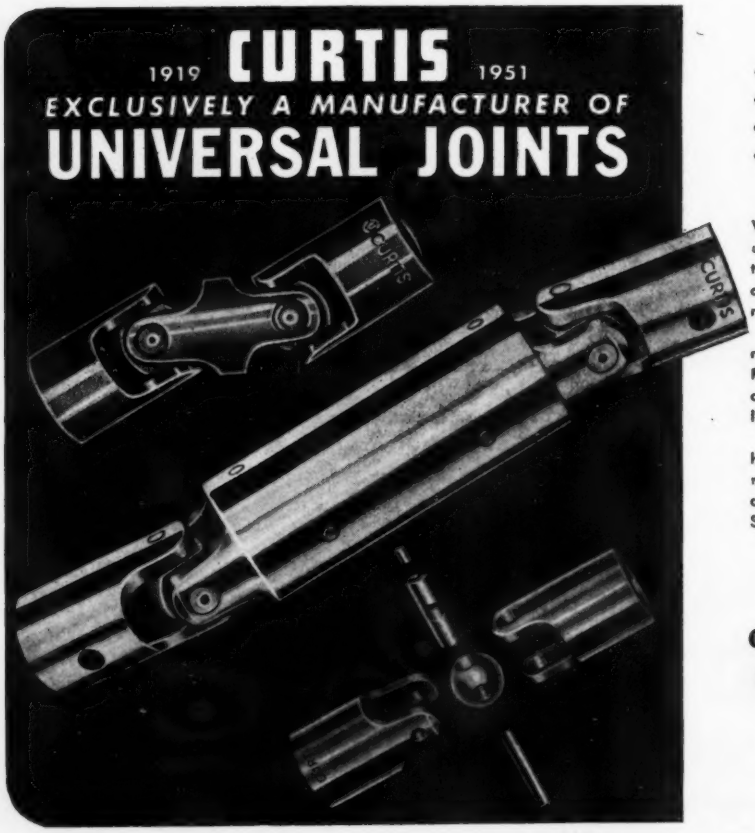
It thus becomes apparent that the United States must have an adequate merchant fleet at all times. The safety and well-being of our national security, in war and peace, demand that the merchant marine be a dual-purpose fleet composed of the best possible ships. Is it not then wise and sound to plan and work toward that goal? It is the belief of the Maritime Administration that the Mariner program is a step in that direction.

The beginning of the end of the wartime effectiveness of the Liberty-Victory class of merchantmen came with the development of such electronic arms as guided missiles; with improved models of target-seeking torpedoes that can be fired accurately from great distances; with the threat of atomic bombing of targets, such as a convoy of ships would provide. Such developments amply fortify the belief that the best way to run ships under wartime conditions today is to run them independently, without convoy. In this way any targets available to enemy attack – whether from aircraft, guided missiles, A-bombs, or naval craft – are made as uninviting and small as possible. All this is not to say that the Mariner class of ships is the perfect solution to the threats of modern warfare against shipping. Nor is it to say that the new class of vessels will be the ultimate in speedy, efficient bottoms for commercial needs. Instead, it is felt that the Mariner class represents a cross section of maritime thinking. Certainly the construction program for the Mariners represents affirmative action on the part of the United States Government to provide this country with the nucleus of a merchant-type fleet before a full-fledged emergency arises.

If the introduction of the Mariner vessels proves anything, it points up the need for still further advancement in the science of naval architecture and in shipbuilding. Surely in the foreseeable future, atomic power will be adapted to things other than bombs. Even now the United States Navy is at work on an atomic-powered submarine and it follows that when undersea craft can utilize this massive source of energy, the day will not be far distant when such power can propel our merchant ships as well.

This article has discussed at length the need for new shipping as an auxiliary to the military. The need also exists to provide improved vessels for strictly commercial use. Objections to the Mariner class ships for the peacetime merchant fleet have been voiced on the grounds that the vessels are too large for economical and efficient operation; that their speed is not

(Continued on page 424)



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Report for the Year 1950

For the second calendar year since the war, new loans made exceeded repayments on outstanding notes, these totals for 1950 being $149,562 and $67,987, respectively. By December 30, 1950, 2,279 men — nearly three-quarters of the 3,144 receiving loans since the Fund was established in 1930 — had completely discharged their financial indebtedness to it.

The data given below summarize the Fund's transactions during 1950 together with cumulative figures for the past nineteen years.

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Cambridge
March 1, 1951

CUMULATIVE RECORD OF THE TECHNOLOGY LOAN FUND TO DECEMBER 30, 1950

	At Dec. 30 1950	*At Dec. 30 1949*	*Net changes during 1950*
Items Of Outgo:			
Number of men Receiving Loans	3,144	2,935	up 209
Total Amount Loaned	$2,253,879	$2,104,317	up $149,562
Average Per Capita Loan	$ 717	$ 717	
Items Of Income:			
Number of Men Whose Indebtedness has been Completely Discharged	2,279	2,185	up 94
Principal Repayments in Advance	$ 601,914	$ 582,565	up $ 19,349
Other Principal Repayments	$1,176,223	$1,127,585	up $ 67,987
	$1,778,137	$1,710,150	up $ 48,638
Total Principal Matured, Considering "Advance Repayments" as Matured, when Paid	$1,810,287	$1,743,299	up $ 66,988
Collection Ratio, i.e. Percentage of Total Maturities Paid	98.2	98.1	up 0.1
Matured Principal in Arrears	$ 23,390	$ 24,581	down $ 1,191
Actual "Written Off" Accounts	$ 8,760	$ 8,569	up $ 191
Total Maturities Unpaid	$ 32,150	$ 33,150	down $ 1,000
Percentage "Written Off" to Total Loans	0.38	0.4	down 0.02
Percentage Matured Loans in Arrears plus amount "Written Off" to Total Loans	1.43	1.58	down 0.15
Interest Received	$ 231,855	$ 227,573	up $ 4,282
Times Interest Received to Matured Loans in Arrears plus Amount "Written Off"	7.2	6.9	up 0.3
Notes Outstanding	$ 466,982	$ 385,598	up $ 81,384

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ROLE OF THE "MARINER"

(Continued from page 422)

needed on global trade routes. Similar arguments were advanced when Robert Fulton first put steam to work on water; when the S.S. *Savannah* made the first Atlantic crossing; when the United States built the first of the C-type vessels shortly before World War II. If the maritime industry is to keep pace with the advances in other fields of transportation, however, it must constantly seek out ways of doing its job more quickly and efficiently.

Just what would constitute a completely ideal merchant ship around which the United States should plan and build its dual-purpose fleet is a question the satisfactory answer to which requires the best available brains. Since the American merchant marine, in effect, is a partnership of private shipping, the government, the military (and don't forget the taxpayer), the future must be the concern of virtually everyone. It almost goes without saying that too few people understand the importance of maritime matters to the over-all future of the free world in general and the United States in particular. Ships are the arteries which carry the lifeblood of trade over all the oceans, and we can no more do without them than we can do without our highways and railroads.

As for the nation's dependence on the merchant marine as an arm of its defense, we need only consider the record in World War II, when merchant ships were called on to carry 7,000,000 men, 203,000,000 tons of dry cargo, and 64,000,000 tons of petroleum products from the United States across the world's oceans. Merchant ships were converted for use as naval auxiliaries — as troop carriers, hospital ships, warship and airplane tenders, airplane and tank carriers, and repair

(Continued on page 426)

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ROLE OF THE "MARINER"

(Continued from page 424)

vessels. Some took part in the actual fighting. Their own guns, manned by naval gun crews or sometimes by the civilian crews, fought off enemy aircraft and submarines.

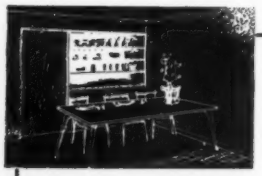
In the early days of our country, the merchant marine was important not only to the growth of a great trading nation but also to its very survival in many critical wars. The fast and maneuverable vessels built by the early American colonists gave them an advantage in opening new avenues of trade and in combating the enemies of the young nation. Merchant privateers were the mainstay of American sea power during the American Revolution, capturing British ships, weapons, and supplies, and damaging British trade. The Navy itself was improvised out of merchant ships and fishing schooners taken over by the government and manned by merchant marine officers like John Paul Jones and John Barry.

After the Civil War, however, the merchant fleet did not receive the support required to enable it to meet its obligations to the national defense. As the country's interest turned to continental development and expansion, shipping was neglected and rapidly deteriorated. In the Spanish-American War, the Army and Navy had to buy foreign shipping. For the most part, transport demands of World War I had to be met by British and French vessels, for the United States had dropped to fifth rank among maritime nations, and its fleet was old and slow. The emergency shipbuilding program instituted in 1917 succeeded in glutting the postwar market with hurriedly built vessels.

In spite of this costly experience, many of the same mistakes were made before World War II. Fortunately, needed reforms were instituted with the passage of the Merchant Marine Act in 1936, which provided for the payment of construction and operating-differential subsidies to builders and operators of American-flag vessels. The act also provided that every vessel built with the aid of government subsidies must be suitable for use as a naval auxiliary and must be so approved by the secretary of the Navy. Furthermore, features incorporated in new vessels for purely national defense purposes were to be paid for by the government in addition to subsidies.

The Merchant Marine Act, 1936, gave us a head start on the building of some modern cargo vessels

(Concluded on page 428)



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ROLE OF THE "MARINER"

(Concluded from page 426)

and tankers which were immediately available for war service. To meet the tremendously increased shipping demands of full-scale war, we made a prodigious shipbuilding effort, which resulted in the production of 5,500 vessels in four years. We paid a high price for them in man power, materials, and dollars.

Our job now is to see that the merchant marine is not a weak link in our economy and defense. The accomplishment of this aim requires an active interest in the problems of shipping and an active attempt to solve those problems. There is room in the maritime industry for men of vision who can pass along, to the nation as a whole, the need of a strong, efficient, and expanding merchant marine; the need of such a fleet is imperative to the welfare of America and all who desire to live in freedom from fear, want, and oppression.

Most definitely the future of America's shipping does not lie in having one type of ship any more than it lies in manufacturing any one type of a given product, or raising any single agricultural commodity. Instead, the nation needs a well-rounded merchant marine — a fleet of large, speedy, and comfortable passenger ships; a fleet of efficient and fast tankers; a fleet of dry-cargo vessels which surpasses anything else on the sea lanes. In short, the United States requires and should have the finest, not necessarily the largest, merchant marine the world has ever known. To accept anything less is to hedge on our responsibility of world leadership of the countries which believe in the freedom of mankind.

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(Continued from page 403)

with great precision, and by means of an adjustable nozzle a uniform stream of water can be produced of any desired depth and velocity within the capacity of the pumps. A large range of the Mach number characteristic of supersonic flow may thus be simulated. Obviously this channel is also extremely useful for the study of such high velocity flow of water which has no counterpart in aerodynamics, but is of interest only to the hydraulic engineer. It has been extremely helpful in the demonstration of such phenomena and is a prime example of the intimate correlation possible between our research activities and educational aims.

This reciprocity between teaching and research is also evident in the facility devoted to a detailed study of the characteristics of water waves. These depend on the depth of water and on the mode of generation. Solitary or single waves, whose wave length is large compared to the depth, were the first object of our studies, which are supported by the Office of Naval Research, and it is hoped that we may continue to the other end of the spectrum, so to speak, formed by the oscillatory waves of small wave length compared to the water depth. A lucite flume, permitting observations anywhere along its length through the bottom or its sides, has proved a useful tool for these studies. In addition to the measurement of wave shape and wave velocity, internal motions made visible by

(Continued on page 430)

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NEW HYDRODYNAMICS LABORATORY

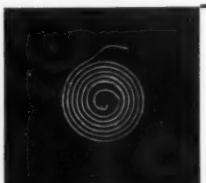
(Continued from page 429)

the stroboscopic observation of discrete suspended particles are explored systematically. Wave action on erodible beaches and on solid structures will provide further problems of interest to hydraulic engineers.

In recent years the Office of Naval Research has also given its support to the development at M.I.T. of a novel test stand for the study of fluid resistance under transient flow conditions. A pilot model of an "unsteady flow water tunnel" has been erected which consists essentially of two reservoirs connected by a short tube or test section. Water is forced from the upper tank through the test section into the lower tank while pressures are controlled to produce the desired accelerated motion. This facility in its present size serves primarily for the solution of the many instrumentation problems connected with the instantaneous measurement of pressures and velocities and with the control of the accelerated water flow. However, to a limited degree experiments on resistance and cavitation inception will be possible which cannot be carried out with the normal water tunnel, in which a steady circulation is maintained as in the customary wind tunnels. The tunnel in question is somewhat analogous to the supersonic tunnels of the blow-down type in aerodynamics, except that two fluids are involved. For immersed bodies, however, a much larger unit will be needed. It is anticipated that the required unit can be built upon the successful development of the present program.

The United States Public Health Service is the sponsoring agency of an extensive program which deals with the experimental definition of the basic factors entering into the aeration processes in the course of sewage treatment. In sewage plants, air is bubbled continuously through the liquid to supply the oxygen needed for the biological decomposition and also to promote the steady mixing of the treated liquid. The oxygen transfer related to air-bubble size and concentration is studied in an aeration column, in which the oxygen concentration of the water may be raised from the lowest limit to saturation under accurate control. Experiments with pure oxygen have also been made. The aeration characteristics have been recorded with the aid of a specially developed oxygen recording system which indicates the temporal values of the dissolved oxygen over the entire test period.

(Continued on page 432)



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NEW HYDRODYNAMICS LABORATORY

(Continued from page 430)

Also of general interest are two basic studies dealing with the measurement of the degree of turbulence in open-channel flow and with the inception of sediment motion along a stream bed. Some success has been achieved in combining a Pitot tube with a pressure cell for the determination of turbulent velocity fluctuations in water, and a series of experiments has been made to probe into the variations of the statistical properties of the turbulence existing in streams in various states of motion. Closely connected to the turbulence problems are the mechanics of sediment transport; some attempts at experimental correlation are under way and some promising observations have been obtained at the beginning stages of the movement of sediment along the bed of a stream.

It is evident that in practically all research problems instrumentation and measuring techniques assume a key role, and the development of new methods, or the adaptation of older ones, becomes a necessary phase of all experimental programs. Amongst its staff of graduate research assistants and associates, the Hydrodynamics Laboratory therefore has electrical and chemical engineers in addition to the mechanical and civil engineers interested in experimental hydrodynamics and hydraulic engineering.

Future Plans for M.I.T.'s Hydrodynamics Laboratory. Future facilities for research include, primarily, a long glass-walled flume extending along the south wall of the main hall which can be used for open-channel flow, for model work on spillways and stilling basins, and for research on waves and surface resistance. The flume is projected as a universal testing utility planned to be used in sections or in its full length of more than 100 feet. It will be 30 inches wide and 36 inches deep with glass bottom and sides over most of its length.

(Concluded on page 434)

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(Concluded from page 432)

Hydraulic models of harbors, estuaries, and river sections are to be accommodated also on the main floor and in the basement area. In recent years space was not available at M.I.T. to accommodate such work, which will be stressed anew since the new laboratory affords an excellent opportunity to apply and test basic knowledge in the solution of many engineering problems, and in turn stimulates the pursuit of fundamental work.

Modern technology brings ever new problems to the fore also in hydrodynamics, and technical personnel trained to cope with them is wanted in fields only remotely suggestive of applications in this field. Many complex problems in the paper industry, in textile manufacturing plants, in mining and ore-dressing, and in the chemical industry have come to our attention.

It is our hope that the new Hydrodynamics Laboratory at M.I.T. will take its place of service to industry and public agencies in line with the Institute's well-established tradition, and that it will grow organically into a position which national and regional needs impose with respect to staff, students, and facilities.

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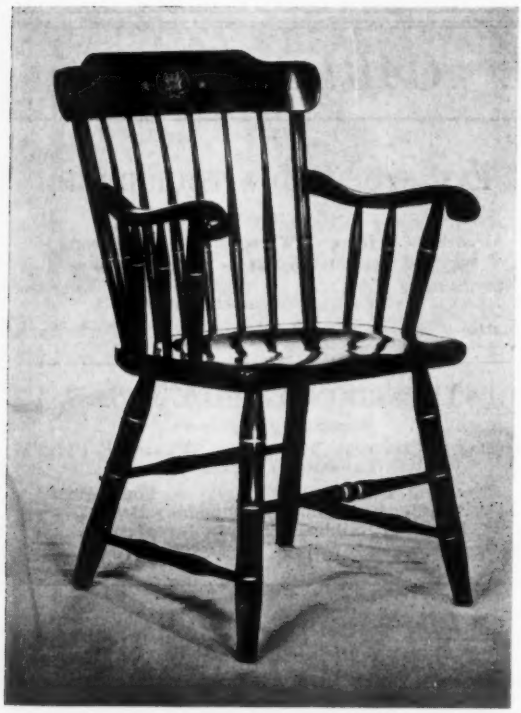

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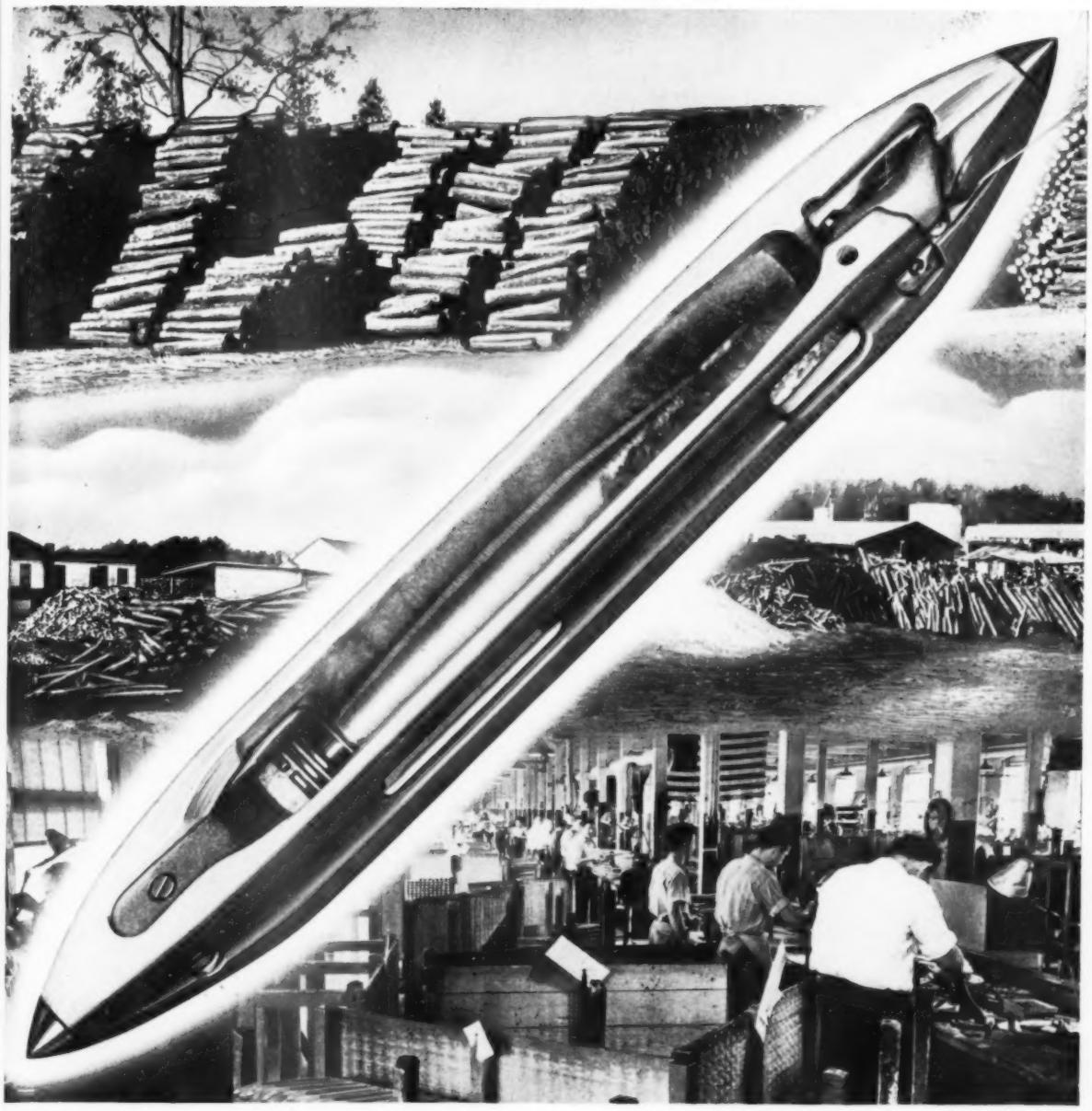

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20 cycles to 20 kilocycles, into 150 or 600 ohms, balanced or grounded. Output of 15 watts is provided between 50 and 15,000 cycles.

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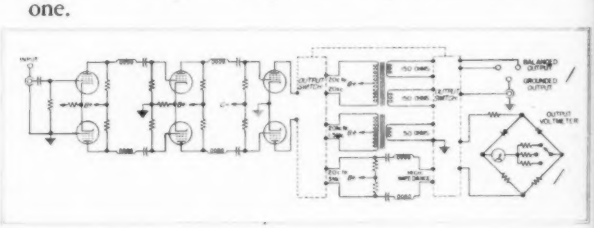
20 cycles to 3 megacycles; output 150 volts peak-to-peak, for a high impedance load with a gain of 60 db. With grounded output, voltage is limited to 50, peak-to-peak, with a gain of 54 db.

The 20 cycle to 3 Mc output is intended for use as an oscilloscope deflection amplifier. The maximum output is secured in all cases with an input voltage of 0.2 volt. Distortion is below 3% at maximum output over most of frequency range. Noise is between 60 and 70 db below 15 watts.

The instrument is provided with a diode voltmeter with full-scale ranges of 150, 50 and 15 volts to indicate the output voltage.

The high voltage power supply uses selenium rectifiers in a full-wave voltage-doubling circuit and a two-section LC filter. A bias supply, using selenium rectifiers, provides fixed voltages for the output stage.

This amplifier brings to the development and laboratory technician an instrument of considerable value in that in one instrument a source of audio and r-f amplification of very high gain and very good frequency characteristic is available at considerably less cost than that required to develop and construct an amplifier or a series of amplifiers equal to the performance of this one.



The basic circuit consists of three push-pull broadband amplifier stages and three output circuits, selected by a switch. Interstage couplings are the series-peaked type, designed for constant gain up to 5 Mc. The input stage operates as a phase inverter.

Separate output transformers are used for the 20 cycle to 20 kilocycle and 20 kilocycle to 1.5 megacycle ranges. Both transformers are toroidally wound. Special care was necessary in the design of these transformers to achieve satisfactory performance at the relatively high frequency at which they operate. Both the leakage reactance between the primary and secondary windings and the distributed capacitance of the primary are limiting factors in determining the high-frequency performance.

Polystyrene cups are used as the interwinding insulation to keep the capacitance of the insulation at a minimum.

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